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New Species of Leafhoppers from Canada (Homoptera: Cicadellidae)[1]

By Bryan P. Beirne[2]

Systematic Entomology Unit, Entomology Division, Ottawa, Canada

The following are descriptions of a new species of the subfamily Typhlocybinae from northern Canada, and one new species of the subfamily Deltocephalinae from Eastern Canada and a second from the Prairie Provinces. The type material is in the Canadian National Collection, Ottawa.

***Dicranoneura frigida* n. sp.**

Length: 3.5-3.75 mm. Yellowish-brown; forewing yellowish on clavus and veins, smoky in apical region, and with costa and commissure sometimes narrowly brown. Vertex blunt, rounded, more than twice as wide between the eyes as its median length. Male plates each weakly curved; rather stout with a short, inwardly directed, pointed projection at apex and a stout inwardly directed, blunt projection below this; aedoeagus short, apical region straight and directed upward and backward, main body of shaft from basal region to base of apical region about three times as long as its greatest width in lateral view, and with a low, but distinct, rounded prominence on dorsal surface near middle.

The form of the aedoeagus, in lateral view, in conjunction with the blunt lowermost apical projection of the plate, is distinctive. Paratypes of the majority of the North American species of *Dicranoneura* (=*Forcipata*) were lent for examination by Dr. D. M. DeLong, Ohio State University. Of these species, only *acantha* (DeL. and Cald.) has the lowermost of the apical projections of the plate not pointed, but it is a smaller insect than *frigida* with the vertex distinctly angled and more sharply produced. Species that have the apical region of the aedoeagus acutely angled with the main axis of the shaft have the shaft relatively much longer than that of *frigida*, as well as differing in the form of the male plates.

Holotype, ♂:—On tundra, Deer River, Mile 473, Hudson Bay Railway, August 3, 1952 (J. G. Chillcott). No. 6251 in the Canadian National Collection.

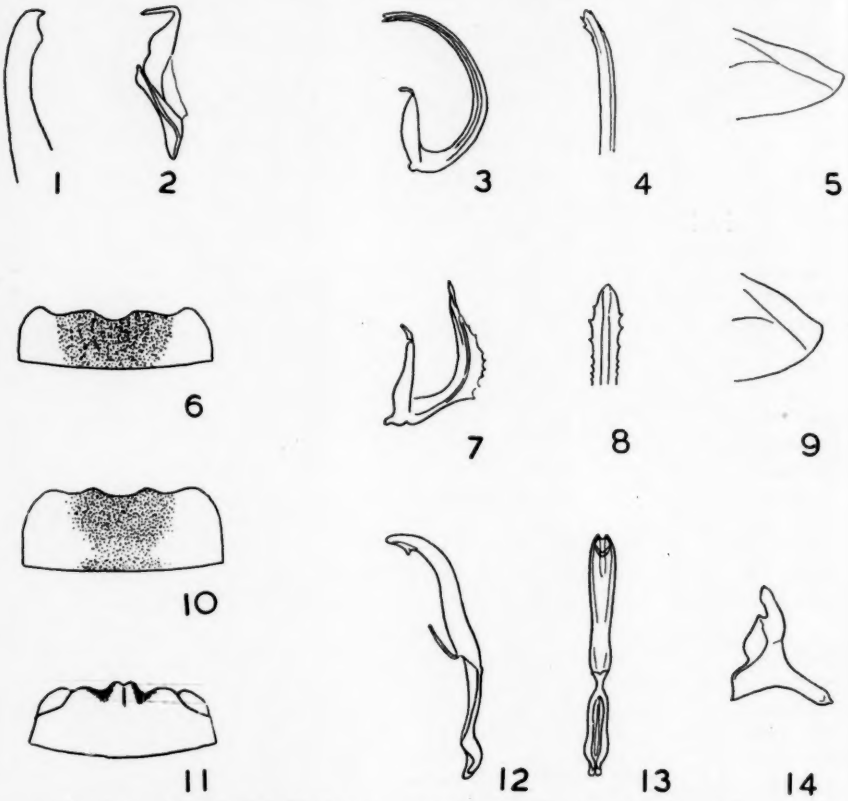
Paratypes:—3 ♂ ♂, same data as holotype; 1 ♂, Farnworth Lake, near Churchill, Manitoba, July 22, 1952 (J. G. Chillcott).

***Athysanella (Amphipyga) longicauda* n. sp.**

Length: ♂, 2.75-3.0 mm., ♀, 3.5-4.0 mm. Light brownish-ochreous; vertex with two large black spots and a small median black spot at anterior margin, a pair of small, triangular, dark spots near apex, and usually a brownish suffusion on disc at either side of mid line; pronotum with irregularly rounded, brown or fuscous markings near anterior margin; scutellum with central area brown or fuscous; forewing streaked with brown or fuscous between the veins; abdomen with a brown or fuscous lateral line, a similar, broader line inside this, and a pair of brown or fuscous spots on each segment between the latter line and a pair of brown or fuscous median lines. Vertex rounded, about one and a half times as long at middle as next the eye; brachypterous; male pygofer tapering, bluntly pointed at apex; aedoeagus long, slender, recurved, slightly asymmetrical

[1]Contribution No. 3327, Entomology Division, Science Service, Department of Agriculture, Ottawa Canada.

[2]Senior Entomologist.



Figs. 1, 2. *Dicranoneura frigida* n. sp. 1, plate; 2, lateral view of aedoeagus.
Figs. 3-6. *Athysanella* (*Amphipyga*) *longicauda* n. sp. 3, lateral view of aedoeagus; 4, posterodorsal view of apical region of aedoeagus; 5, apical region of male pygofer; 6, female seventh sternum.
Figs. 7-10. *Athysanella* (*Amphipyga*) *acuticauda* Bak. 7, lateral view of aedoeagus; 8, posterodorsal view of apical region of aedoeagus; 9, apical region of male pygofer; 10, female seventh sternum.
Figs. 11-14. *Lonatura crocea* n. sp. 11, female seventh sternum; 12, lateral view of aedoeagus and connective; 12, ventral view of aedoeagus and connective; 14, style.

toward apex, ornamented with spines at extreme apex only; female seventh sternum with posterior margin emarginate at middle, postero lateral corners slightly produced, and central area striated.

This species has been confused with *acuticauda* Bak., which it resembles on a basis of external characters. It differs in the much longer, more slender, and more strongly curved aedoeagus, which is ornamented with spines only at its apex; the aedoeagus of *acuticauda* (Figs. 7, 8) has two large flanges with spined margins on its postero-ventral surface from before the middle to the apex. Other differences between the two species are the relatively broader male pygofer (Fig. 9), the shorter apical region of the style, and the longer female seventh sternum (Figs. 10) of *acuticauda*. Moreover, *longicauda* appears to be confined to the East whereas *acuticauda* occurs mainly in the grassland regions of Alberta, Saskatchewan, and Manitoba, though it has been found in Quebec, at Kazubazua.

Holotype, ♂:—Merivale, Ontario, May 23, 1932 (G. S. Walley). No. 6253 in the Canadian National Collection.

Allotype, ♀:—Same data as holotype.

Paratypes:—17 ♂♂, 22 ♀♀, same data as holotype; 2 ♂♂, 1 ♀, Carp, Ontario, May 20, 1954 (R. Hollinsworth); 2 ♂♂, Blackburn, Ontario, June 16, 1951 (E. H. N. Smith); 1 ♀, Blackburn, Ontario, April 18, 1945 (T. N. Freeman); 2 ♀♀, Bell's Corners, Ontario, June 25, 1952 (R. S. Bigelow); 4 ♂♂, 1 ♀, Kirks Ferry, Quebec, May 25, 1950 (B. P. Beirne); 2 ♂♂, 3 ♀♀, Covey Hill, Quebec, June 15, 1927 (G. S. Walley).

***Lonatura crocea* n. sp.**

Length: 4.0-4.5 mm. Brachypterous form ochreous with black ocelli, otherwise without dark markings; macropterous form greyish-ochreous, sometimes with basal triangles of scutellum pale orange and with abdomen brownish-ochreous. Vertex bluntly pointed, about twice as long at middle as next the eye; forewing hyaline, ochreous-tinged, reaching the sixth abdominal segment in the brachypterous form and exceeding the abdomen in length in the macropterous form; aedoeagus and connective fused; aedoeagus long, apical third curved upward, apex bluntly pointed in lateral view, excavated in ventral view, with a dorsal projecting lip near apex that appears in lateral view as a short projection; style short and broad; female seventh sternum with postero-lateral corners emarginate and with rounded plates beneath, and with posterior margin shallowly emarginate at either side of a low, bilobed, brown, median projection.

The form of the aedoeagus is distinctive. Other distinctive features are the style and the combination of the relatively large size, the colour, and the virtual absence of dark markings.

Holotype, ♂ (brachypterous):—Bateman, Saskatchewan, September 18, 1939 (A. R. Brooks). No. 6254 in the Canadian National Collection.

Allotype, ♀ (brachypterous):—Same data as holotype.

Paratypes:—6 ♀♀ (brachypterous), same data as holotype; 1 ♂ (brachypterous), Elbow, Saskatchewan, August 15, 1951 (A. R. Brooks); 2 ♂♂ (macropterous), Aweme, Manitoba, August 1, 1930 (N. Criddle).

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Studies on Flight Range and Dispersal Habits of *Aedes flavescens* (Müller) (Diptera: Culicidae) Tagged with Radio-phosphorus[1]

By J. A. Shemanchuk[2], F. J. H. Fredeen[3], and A. M. Kristjanson[4]

In Western Canada, *Aedes flavescens* (Müller) is found mainly on the prairie, where it is one of the commonest of the blood-sucking pests of livestock and man. It has also been taken as far north as Churchill, Man., and Alaska (Rempel, 1950). Information on its flight range is useful in planning control programs. Field and laboratory studies on the flight range of this species, with radio-active phosphorus for tagging, were conducted at Saskatoon and Indi, Sask., in 1952. The project area is almost flat in the north and west and rolling in the south and east; the Blackstrap Valley separates the two topographical areas.

Methods

The method used in radio-active tagging was essentially that reported by Fredeen *et al.* (1953) and Shemanchuk *et al.* (1953), whereby relatively mature black-fly and mosquito larvae were placed for 24 to 48 hours in a dilute solution of radio-active phosphorus, and then were returned to their native habitat for development to adults. From two sloughs at Indi, Sask., containing large numbers of larvae of *A. flavescens*, larvae were collected by hand with large nets made of fine plastic screening, placed in a tub, and separated as well as possible from the debris and organic matter. In each tub, approximately 45,000 larvae were placed in 45 litres of water containing 0.1 μc. of P^{32} per ml. After approximately 24 hours, 10 larvae were taken from each tub, washed thoroughly in fresh water, and dried. The radio-activity was determined with a portable beta-gamma survey meter. If the average radio-activity of the larvae was more than 3,000 dis. per min., the larvae remaining in the tub were returned to one of the sloughs to complete their development to adults; otherwise they were left in the radio-active solution for approximately another 24 hours.

The solutions were used repeatedly, but had to be boiled every second day to destroy putrefying bacteria. Radio-active phosphorus was added to the boiled solutions to keep them at the 0.1 μc. of P^{32} per ml. level.

On several occasions larvae took up less radio-activity on cool than on warm days. To determine the effect of temperature on uptake of radio-active phosphorus, duplicate batches of 100 fourth-instar larvae were placed in glass beakers containing 100 ml. of pond water and 0.1 μc. of P^{32} per ml. and kept at 34° and 76°F., respectively. At 20-hour intervals five larvae were removed from each of the beakers, washed, and dried, and the radio-activity was determined.

Also, a laboratory experiment was conducted to determine the maximum concentration of P^{32} that could be used without causing excessive mortality of the larvae or a reduction in the life span of the adults. In three duplicated tests 100 larvae were kept for 24 hours in 100 ml. of pond water containing concentrations of 0, 0.1 and 1.0 μc. of P^{32} per ml. The larvae were then transferred to beakers containing pond water for rearing. Before adults emerged, each beaker was placed in a separate, screened cage so that the life span of the adults could be determined.

For recoveries, adult mosquitoes were collected from May 17 to June 20. Most of the collections were taken within a few miles of the slough that contained the tagged larvae; a few were taken at greater distances, up to 14 miles

[1]Contribution No. 3301, Entomology Division, Science Service, Department of Agriculture, Ottawa, Canada; in co-operation with the Department of Chemistry, University of Saskatchewan, Saskatoon, Sask.
[2]Assistant Entomologist and [3]Associate Entomologist, Veterinary and Medical Entomology Section, Entomology Laboratory, Saskatoon, Sask.
[4]Assistant Professor, Department of Chemistry, University of Saskatchewan, Saskatoon, Sask.

from the release site. Most of the mosquitoes were collected with hand sweep-nets from vegetation, livestock, and man in low-lying pasture land. Two New Jersey mosquito light traps and two kerosene lamp traps were used but were ineffective, possibly because of low temperatures after dark. Mosquitoes collected in the nets were killed and placed in cardboard cartons for transportation to the laboratory.

These mosquitoes in batches of approximately 1,000 were spread thinly on paper, and an end-window Geiger tube attached by a flexible cord to a radiation scaler was slowly passed over the surface as close as possible to the insects. Radio-activity was detected and the tagged insect isolated for determination of species and amount of radio-activity.

Results and Discussion

Approximately 415,000 larvae of *A. flavescens*, the majority in the fourth instar, were tagged with radio-active phosphorus and returned to the slough from May 10 to May 17 (Table 1). The tagging of the larvae required approximately 400 man-hours of work, of which 90 per cent was spent collecting the larvae and separating them from debris. The radio-activity of these larvae, after having been kept in a solution of 0.1 μc. per ml. of P^{32} for 19 to 45 hours, averaged 8,130 dis. per min., with a range of 1,300 to 22,400. The exposure

TABLE I

Record of Daily Releases of *Aedes flavescens* Larvae Tagged with Radio-active Phosphorus, Indi, Sask., 1952

Lot no.	Date of release May, 1952	No. of larvae treated	Period in 0.1 μc./ml. solution hr.	Radio-activity of 10 larvae from each lot, dis./min.	
				Average	Range
1	10	27,000	45	4,500	2,500 — 5,800
2	11	6,000	20	6,700	4,500 — 13,400
3	12	20,000	44	6,700	3,600 — 11,000
4	12	22,000	43	4,500	1,300 — 8,100
5	13	30,000	29	9,800	8,100 — 10,300
6	13	15,000	25	9,000	5,800 — 10,300
7	14	50,000	19	18,000	4,500 — 22,400
8	14	30,000	20	15,700	6,700 — 20,000
9	14	35,000	22	7,800	2,200 — 13,400
10	15	45,000	28	5,600	4,500 — 7,600
11	16	50,000	44	4,500	2,200 — 6,700
12	16	20,000	41	5,600	3,400 — 6,300
13	16	40,000	22	6,700	4,500 — 8,100
14	16	5,000	22	11,000	5,400 — 18,000
15	17	20,000	24	5,800	3,100 — 6,300

period had to be lengthened during cool weather to 41 to 45 hours to obtain larvae with optimum amounts of radio activity.

Laboratory tests showed that temperature affects the amount of P^{32} taken up by the larvae. The uptake of P^{32} at exposures of 15, 40, and 60 hours was 1,250, 2,860, and 3,320 dis. per min. at 34° F., and 33,000, 82,200 and 121,000 dis. per min. at 76° F. In a 60-hour exposure the amount taken up at 76° F. was more than 35 times that taken up at 34° F.

In the experiment on the effect of concentration of P^{32} on the life spans of larvae and of the adults that emerged from them, mortality of larvae, within four days after treatment, averaged 36.5 per cent in the checks, 41 per cent in the 0.1 μc. treatments, and 100 percent in the 1.0 μc. treatments. Adults began to emerge five days after treatment in the checks and eight days after treatment in the 0.1 μc. tests.

An estimated 1,500,000 adult mosquitoes were collected from May 17 to June 20 inclusive from 70 points near the release site and at distances up to 14 miles. Eighty-two radio-active mosquitoes, 0.02 per cent of the tagged larvae, were taken from May 21 to June 6 (Table II). Their average radio-activity was approximately 560 dis. per min., with a range of 60 to 9,000.

Comparison of the average radio-activity of larvae and of adults indicated a loss of radio-activity of 93 per cent. Decay of P^{32} during this period would account for a loss of approximately 56 per cent, and the remaining loss, 37 per cent, was thus apparently the result of excretory processes.

A larger amount of radio-activity in some of the adults would have made monitoring easier, as much time was lost in picking out mosquitoes with counts

TABLE II

Data on 82 Radio-active Adults of *A. flavescens* Collected in the Field from May 21 to June 6, 1952, near Indi, Sask.

Number of tagged specimens collected	Direction from release site	Distance from release site	Sex F	Sex M	Range of radio-activity in adults dis./min.
5	S	150 – 220 yd.	4	1	120 – 1,500
1	SSE	6.6 mi.	1	0	250
17	SE	40 – 160 yd.	14	3	100 – 550
3	SE	5.2 mi.	3	0	100 – 450
1	ESE	1,000 yd.	1	0	180
13	E	65 – 120 yd.	6	7	75 – 900
2	E	880 yd.	1	1	100 – 200
6	E	2.5 mi.	6	0	80 – 1,500
4	NE	6.2 mi.	4	0	60 – 300
4	NNE	150 – 200 yd.	4	0	100 – 300
1	NNE	1,400 yd.	0	1	150
4	W	40 – 60 yd.	4	0	150 – 300
21	SW	40 – 130 yd.	17	4	75 – 9,000

scarcely above the background count. However, the end-window Geiger tube attached to a scaler was much more sensitive for this work than the portable Geiger counter used in previous tests (Shemanchuk *et al.*, 1953).

Although only 82 tagged adults were recovered, the study produced some information on the dispersal of *A. flavescens*. The females may disperse at least 6.6 miles from their point of emergence. It was impossible to determine the time of emergence of any of the tagged mosquitoes, so that the effect of meteorological and other factors on dispersal is unknown. However, the recovery data indicated that wind may influence the direction of flight, for the majority of the tagged adults collected near the release point, and all of those collected at a distance, had apparently moved with the prevailing wind. There was also an indication that the males fly a shorter distance than the females; although only 17 tagged males were recovered, 15 of them were taken near the slough that contained the tagged larvae, the other two being collected at distances of 880 and 1,400 yards.

More than 82 tagged adults would probably have been taken if collecting had been confined to the vicinity of the release site. Theoretically, the dilution of a free tagged population moving away from a point varies directly as the square of the distance from that point. This would partially account for the small number recovered, as most of the collecting was done several miles from the release point. Also, the collecting was done largely with hand sweep-nets, and the area that could be covered within the short experimental period was limited. To obtain larger recoveries more collectors and improved trapping methods are needed.

Some of the difficulties encountered in this study could be overcome by using larvae reared from eggs in the laboratory. By this means the development of the larvae to the proper stage for tagging could be made to coincide with the arrival of the P^{32}, which has to be ordered weeks in advance. Loss of larvae by predation would also be eliminated.

Summary

Approximately 415,000 larvae of *Aedes flavescens* (Müller) were tagged by keeping them in a 0.1-μc.-per-ml. solution of radio-active phosphorus for 19 to 45 hours and returning them to their natural habitat. From 1,500,000 adults collected with hand nets as far as 14 miles from the emergence site, 82 tagged mosquitoes (0.02 per cent of the tagged larvae) were obtained: females as far as 6.6 miles and males 1,400 yards from the release site. The average radio-activity of larvae was 8,130 dis. per min. and of adults 560 dis. per min., indicating a loss of 93 per cent of the original radio-activity, of which approximately 56 per cent could be accounted for by decay of the P^{32}. Larvae kept for 60 hours in cold (34°F.) 0.1-μc.-per-ml. P^{32} solution were one-thirtieth as radio-active as larvae reared in warm solutions (76°F.). All larvae kept for 24 hours in a 1.0-μc.-per-ml. solution died within four days after the treatment. Larvae kept in a 0.1-μc.-per-ml. solution emerged slightly later than those kept in untreated water, but there was no appreciable difference in the life span of the adults that emerged from these larvae.

References

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The Concept of Survival in Preference to That of Mortality[1]

By R. W. SALT[2]

Field Crop Insect Section, Science Service Laboratory, Lethbridge, Alberta

The application of lethal agents of any kind in entomological research is usually aimed at the determination of mortality as related to such factors as dosage, temperature, and time. Mortality is the yard-stick and survivors merely the fraction that did not die. After an arbitrarily selected interval the experimental material is categorized as dead or alive, with sometimes an intermediate group such as "subnormal" inserted. This third class is often essential, for its members do not properly qualify as dead or alive, terms that imply totality. It is also a nuisance, for several reasons: (1) it blends gradually into the other two categories so that classification itself is subject to errors of judgment; (2) its numerical uncertainty affects the other categories not only at the time of initial classification but also later by the death or total recovery of some of its members; (3) as long as any treatment-effect persists, the situation remains quantitatively incomplete.

It may be argued that straightforward counts of dead experimental animals at a given time are satisfactory for purposes of comparison, e.g., when a chemical toxicant is applied at different dosages, other factors being maintained constant. But this is not completely justifiable, as a consideration of the survivors will show. Some will have survived a low dosage and others a high one, and hence their prospects for effective survival* will be different. Those surviving a high dosage were more resistant to the particular lethal factor than those that died, and in all probability they also possessed superior attributes of other kinds, both physical and physiological. However, such insects are also spared by a low dosage. In general, therefore, an insect surviving a weak lethal factor is a better prospect for ultimate survival than one surviving a strong one.

A further objection to using mortality for comparative purposes depends on differing modes of action of lethal agents. Some of these produce serious and lasting effects in the survivors, and others produce effects that are less vital or more easily overcome. Lethal factors that act on the all-or-none principle, that either kill or leave no ill effect, are exceptions to which the arguments in this paper will not apply. Lethal freezing after a normal amount of supercooling is an example.

Still another objection to arbitrary mortality counts is psychological. Because of the ease with which they are quantitatively determined, mortality data are very suitable for statistical analysis. One is apt to be deluded into thinking that the analysis allows for all contingencies, but the one thing it cannot do is to compensate for incorrect raw data. If survival data are uncertain, how can mortality data be less so? Statistical treatment of such data is deluding.

The writer was recently associated with some experimentation that demonstrates well the difference between a typical measurement of mortality and the more realistic but difficult measurement of survival. In these experiments all stages of the rusty grain beetle, *Laemophloeus ferrugineus* (Steph.), were exposed to constant, moderately low temperatures for various periods of time. After exposure, they were returned to the original rearing conditions and their progress was recorded daily. Outright mortality could thus be determined at any

1Contribution No. 3325, Entomology Division, Science Service, Department of Agriculture, Ottawa, Canada.

2Principal Entomologist.

*In this paper *survival* refers to the living state, no matter how tenuous; *effective survival*, or *ultimate survival*, implies survival to the point of effective reproduction.

time. It was decided, however, that each individual should demonstrate its ability to survive. To be counted as survivors, eggs were required to become pupae, and larvae, prepupae, and pupae had to become adults. Normal appearance was also a requisite. Because of difficulties of determining sex and mating, and providing adequately for progeny, adults could not be reared like the other stages and are therefore excluded from this discussion. Survival of controls was virtually perfect; any effect other than normalcy was thus attributable to the treatment.

It is apparent that mortality and survival as outlined above differ from those recorded at a selected interval after exposure. Regardless of the relative ease of the latter method, realistic thinking will certainly favour a method that takes into consideration the progress of the survivors, for the future of the population hinges on them. It will often be difficult to determine ultimate survival, and sometimes impossible, when the treatment-effect extends into future generations, but this is insufficient reason for rejecting the principle entirely. A compromise, as in the example given, where survival to a reasonable point was specified, is much preferable to an arbitrary mortality count.

It may be of interest to consider the plight of, for example, a young rusty grain beetle larva that has survived a period of chilling that killed 50 per cent of its fellows. To assume that this larva and the remainder of the survivors are quite normal is clearly wrong. On the contrary, it is to be assumed that the chilling has produced direct and indirect effects of various kinds that, so far at least, have not become additively lethal. Since the larva is not dead, it still retains some chance of remaining alive; the size of this chance, the probability of recovering sufficiently to play a part in perpetuating the species, is a measure of the sublethal effect of the chilling. As the larva continues to live, it is continually meeting situations where its subnormal condition is deleterious. Moulting, pupation, and eclosion are major hurdles that may require more "stamina" than it possesses, although it has sufficient just to remain alive. If the initial damage has not been great, the larva may recover completely. It is important to realize that the lethal factor can produce innumerable shades of effect short of sudden death. Against this, the organism possesses powers of recovery. It may be "touch and go" for some time, and in such circumstances, events that would otherwise be of minor importance may become vital. In this connection it is of interest to note that because of the widely variable intensity of sublethal effects a large number of individuals are required in an experiment to ensure uniform quantitative results when mortality is the information sought, and a much larger number when the surviving population is to be given adequate consideration.

There is nothing new in the concept advocated in this paper. The literature abounds in examples where survival has been given full consideration. A striking example is that of Lin, Hodson, and Richards (1954), who incubated 9,395 eggs of *Oncopeltus fasciatus* (Dallas) at minimal temperature conditions. Thirty seven per cent burst the egg shell and 13.7 per cent (1,291) hatched completely. Of these, however, only six per cent lived past the first instar, and three (all males) reached the adult stage. The authors point out that if the eggs that hatched did so because of greater hardiness or vigor, "they should have grown readily and given one or more stocks of higher resistance. We are forced to conclude that minimal conditions of rearing give young of such weakened condition that death ensues and that the question of whether death occurs prior to, during, or subsequent to hatching is of little significance." An arbitrary decision to base egg mortality on either shell-bursting or complete hatch would

not only have produced misinformation, but would probably have prevented the discovery of this vital information on survival.

In summary, from the standpoint of a species or a given population, indifference to the fate of organisms surviving a sublethal treatment is insupportable. Although on occasion an arbitrary mortality count may be suitable for comparative purposes or may be the only possible method under the circumstances, the limitations of the data should be recognized. It is sometimes sufficient in the laboratory to consider initial mortality only; in nature this is seldom if ever adequate. Factors such as drought and heat often affect large segments of the population without necessarily killing any of it outright, but the damage is there; because it is not readily observed it is usually overlooked or ignored. There is little doubt that an appreciable share of environmental resistance is attributable to sublethal effects.

Acknowledgements

Criticisms by the staff of the Science Service Laboratory, Lethbridge, of the ideas contained in this paper are gratefully acknowledged.

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Contribution to the Morphology of a Pine Web-spinning Sawfly, *Cephalcia marginata* Middlekauff (Hymenoptera: Pamphiliidae)[1]

By I. Rivard[2]

Biological Control Section, Entomology Laboratory, Quebec, Que.

Introduction

In studies of sawflies, the family Pamphiliidae has been much neglected especially from the morphological stand point. Yuasa (1922) made a study of the larvae, but the genus *Cephalcia* was dealt with rather briefly. Ross (1937) and Benson (1945) made comparative morphological studies of the adults and showed the phylogenetic position of the family. More recently, Middlekauff (1953) published a description of *Cephalcia marginata,* a pine web-spinning sawfly which was the subject of the present study.

Materials and Methods

All insects used in this work were collected and reared at the Laboratory of Entomology, Berthierville, P.Q., by Dr. L. Daviault and his staff during the years 1939 to 1942. With the exception of pinned specimens, the material was preserved in Frehling's solution which unfortunately destroyed the original coloration of these insects. Following dissection, the specimens were soaked in 10% caustic potash (KOH) to free the chitin from its soft parts. To hasten bleaching, the solution was boiled for 2 to 10 minutes, depending on the size of the treated pieces and on the quantity of the soft parts to be removed. This was followed by washing with slightly acidulated distilled water and by rinsing with pure distilled water. They were dehydrated in successive 30%, 50%, 70% and 95% alcohol baths, cleared in xylol and mounted on slides in Canada balsam. Descriptions were based primarily on this treated material; pinned insects were also used to check adult characters. A camera lucida was utilized in making most of the illustrations.

1From a thesis submitted to the Graduate School, Laval University, in partial fulfilment of the requirements for a M.Sc. degree.

2Assistant Entomologist.

Morphology of the Egg

The egg (Fig. 2) is about 2.5 mm. long and 1 mm. in diameter. It is sub-cylindrical in shape, slightly curved-in ventrally and more or less rounded at both ends. Of a uniform whitish green coloration, its surface is smooth and dull in appearance but, if examined under a high power microscope, the chorion shows a delicately reticulated aspect.

Eggs are usually deposited end to end upon the flat surface of old needles to which they are fastened with a varnish-like substance (Fig. 1). They are generally grouped in a single row of 12 to 15 eggs on each needle.

At the end of the embryonic developmental period, the embryo (emb) can be seen through the chorion (ch) which has become transparent at that stage (Fig. 3). The larva hatches through a cleft on the upper part of the egg, and the chorion remains fastened to the needle for an undetermined period.

Morphology of the Larva

Mature larvae (Fig. 4) average 22 mm. in length and nearly 3.5 mm. in diameter with the head capsule about 2.5 mm. in width. Coloration of the larva changes as it develops; it is more or less greyish green when newly hatched and after the last moulting becomes ivory yellow with the head, the legs and the sclerified plates on the thorax and the last abdominal segment reddish brown. Since there is little morphological difference in the various larval instars, the present study was limited to mature specimens.

Head and Appendages

The head (Fig. 19) is almost as wide as the thorax and typically sub-globose and slightly flattened anteriorly. Its surface is reddish brown and has a granulated appearance. It bears scattered setae increasing in number and in length in the ventral area. The clypeus is paler, and the same discoloration occurs along the epicranial suture and the vertical furrows, while the ocularia (oc) are black. The inverted *Y*-shaped epicranial suture is always visible. Its stem or coronal suture (cs) originating at the occipital foramen extends cephalad slightly to the left side, then bifurcates in the upper part of the front. Each arm of the fork or frontal suture (fs) runs laterad for a short distance and bends ventrad ending near the anterior articulation of the mandibles. Along this suture, a small fossa and a thickening of the cuticle indicate the site of the anterior tentorial invagination (at). Each side of the vertex, the vertical furrow (sv) (Fig. 4) originates at the occipital foramen and runs forwards. The front is limited dorso-laterally by the frontal sutures, and ventrally by a transverse depression between the tips of these sutures. This sclerite is somewhat flattened and has two groups of 10 microscopic setae symmetrically laid out (Fig. 19). The clypeus (clp) is limited dorsally by the above transverse depression, but its lateral borders are free, slanting and convergent ventrad. It is much wider than long and made of a single plate. The labrum (lm) (Fig. 11) is a small lobe attached ventrally to the clypeus by two long apodemes (ap). This transverse sclerite is emarginate in the middle part of its ventral border. It has two rows of short setae, one in its median area, the other along its ventral part of the ocularia (oc), which are ovate and located ventro-laterad of the antennariae (ana). The antennae (ant) are attached to the ventro-lateral part of the head and borne on a distinct subcircular antennaria with a wide antacoria ivory in color. They are long, setaceous and composed of 7 articles. The second, third and fifth articles have a minute sensorium on the ventral area of their distal parts and, with the exception of the fifth, each article has a few microscopic setae at its distal portion (Fig. 16).

Mouthparts are well developed and directed ventrad. Typically stout and strongly sclerified, each mandible (Figs. 12 and 13) has three sharp teeth. In the maxillae (Fig. 14), the cardo (cd) is more or less sclerified and subdivided into an elongate subcardo articulating with the head, and a triangular alacardo attached to the base of the stipes (st). The stipes is submembranous as a whole, but more sclerified in its posterior part. Elongate and convex, it is laterally con-

Fig. 1

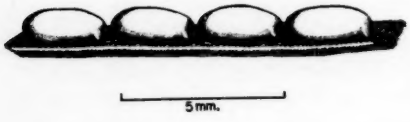


Fig. 2

Fig. 3

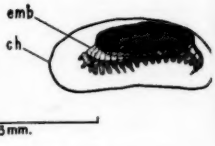


Fig. 4

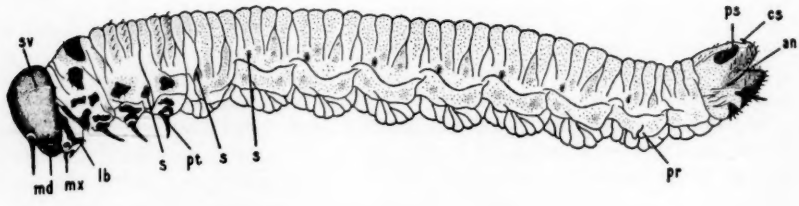


Fig. 5

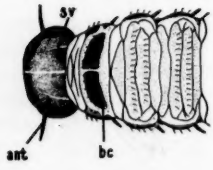


Fig. 6

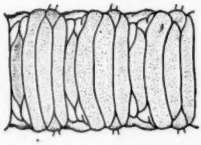


Fig. 7

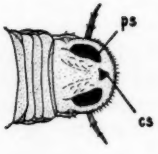


Fig. 8

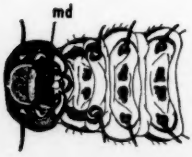


Fig. 9

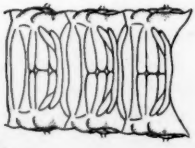
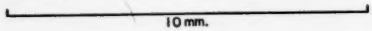


Fig. 10



tinuous with the triangular subgalea (sgl) to which it is fused along an oblique ridge. Near its base, the stipes continues laterally into a small lobe bearing a long stiff seta. In front of this lobe, a partially membranous swelling forms the palpifer (pfr). It supports a short maxillary palpus (pmx) of 4 conical segments. At the tip of the subgalea, a strongly sclerified finger-like process curves towards the labium; this is the galea (gl). The lacinia (lc) is a round lobe more or less membranous at the end of the stipes and continguous to the galea. It carries a row of 7 bristles on its anterior margin. In the labium (Fig. 15), the submentum (sm) is wide and convex, mostly membranous with the exception of a median plate bearing 4 hairs on its anterior border. Anterior to the submentum is the mentum (m), but the line of demarcation is not well defined. It is membranous, with the exception of one median and two smaller lateral crescent-shaped plates. A transverse depression divides the mentum from the stipulae (sti), but there is no suture visible. These have a median sclerified band which widens laterad. The membranous totaglossa (tog) is fused at the base with the stipulae, and the silk gland ducts open on a prominent sericos (ser) near this fusion line. The palpigers are not distinct and their position is indicated only by a swelling of the antero- lateral margins of the stipulae. Each palpiger supports a short palpus (pl) of 3 conical articles.

Thorax and Appendages

The large cervical membrane folds under the anterior part of the thorax (Figs. 4, 5 and 8). It has on each side an elongate cervical sclerite articulating anteriorly with the head and posteriorly with the epimeron and the coxa. Ventrally, it is continuous with the submentum. The prothorax is anteriorly compressed and divided into a narrow cephalic area and a wider caudal area. The cephalic portion is glabrous on the dorsum, but has a small setiferous plate on each side. The caudal portion is covered dorsally with a pair of transverse plates, each of which bears a row of setae on its anterior margin. These plates form the thoracic shield (bc). A smaller similar plate is found on the side of the prothorax. The mesothoracic spiracle, which has migrated cephalad, is located immediately behind this plate. Another pubescent plate, the epimeron, is found below the spiracle, just dorsad of the coxa. The ventral portion of the prothorax is divided into two distinct annulets. The first carries a pair of small setiferous plates, while the second is entirely membranous. The mesothorax and the metathorax are somewhat similar in structure. They are dis-

PLATE I

EGG:

Fig. 1—Group of eggs on a pine needle, lateral aspect.
Fig. 2—Egg, lateral aspect.
Fig. 3—Embryo in egg shell, lateral aspect.

MATURE LARVA:

Fig. 4—Whole larva, lateral aspect.
Fig. 5—Head and thorax, dorsal aspect.
Fig. 6—3rd, 4th and 5th abdominal segments, dorsal aspect.
Fig. 7—8th and 10th abdominal segments, dorsal aspect.
Fig. 8—Head and thorax, ventral aspect.
Fig. 9—3rd, 4th and 5th abdominal segments, ventral aspect.
Fig. 10—9th and 10th abdominal segments, ventral aspect.

Abbreviations

an—anus; ant—antenna; asb—subanal appendage; bc—thoracic shield; ch—chorion; cs—suranal hook; emb—embryo; lb—labium; md—mandible; mx—maxilla; pr—fleshy protuberance; ps—suranal plate; psb—subanal plate; pt—thoracic leg; s—abdominal spiracle; S—thoracic spiracle; sv—vertical furrow.

tinctly ring-shaped and divided on the dorsum into 4 annulets, the two median ones being slightly sclerified and bearing a row of microscopic setae. On each side, a little below the center, these segments have a small triangular pubescent plate. Also in the lateral area, just ahead of the line of demarcation between the mesothorax and the metathorax, there is the metathoracic spiracle. The ventral part of these segments is quite similar to the prothorax.

Fig. 11

Fig. 12

Fig. 13

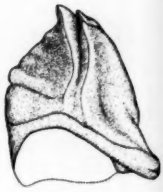
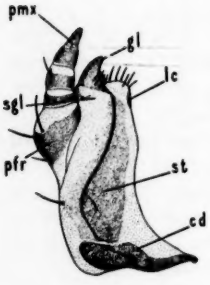


Fig. 14



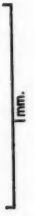


Fig. 15

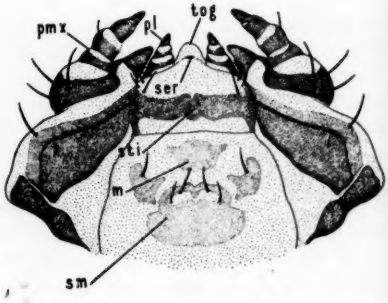


Fig. 16

Fig. 17

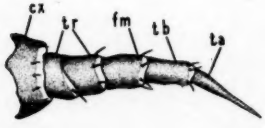


Fig. 18

The three pairs of thoracic legs are attached to the latero-ventral margin of the segments on the lobe-shaped area below the spiracles. They are identical in structure and composed of 5 more or less sclerified articles (Fig. 17). The distal article (ta) representing the fused tarsus and claw is long and sharp. It is glabrous while the others have a few setae at their distal tip. As in the adult, the trochanter (tr) is apparently formed of 2 fused articles. This is indicated by the suture which circles the centre of the article and by the presence of a seta near this suture.

Abdomen and Appendages

The abdominal segments, with the exception of the posterior end, are quite similar and ring-shaped. The third segment being typical and less modified will be used as a basis for the description (Figs. 4, 6 and 9). It is dorsally divided into 4 distinct annulets, and ventrally into 7 more or less differentiated annulets forming a prominent lobe. The spiracle (s) is located on the line of demarcation between the first and second dorsal annulets about midway between the dorsal and ventral parts of the segment. Just below the spiracle, a sinus-shaped fold forms a sublateral lobe which is divided into an anterior or subspiracular area and a posterior or surpedal area. This lobe is slightly sclerified and sparsely setiferous. The eighth segment has a fleshy protuberance (pr) resembling somewhat a pseudopod. Segmentation is always distinct, but the edges of each segment are sometimes poorly defined. The anterior edge is indicated by a transverse depression on the dorsum and the sides, and by short ventro-lateral depressions ending in front of the subspiracular lobes.

The ninth abdominal segment (Figs. 4, 7 and 10) is easily recognized by its shape and the absence of spiracles. It is a little smaller than the preceding segment and tapers backward with only 3 visible annulets on the dorsum and 4 on the venter. Its subspiracular and surpedal lobes are fused to form a lateral oblique fold. The last segment is much modified and quite different due to the presence of the anus (an), of the subanal appendages (asb) and of other particular structures. It is slightly compressed and rounded posteriorly. Its dorsal area is grooved medially by a longitudinal depression and bears 2 elongate suranal plates (ps) on its borders. Between these plates, near the caudal margin, arises a small thorny hook-shaped process representing the suranal hook (cs). The under part of the same segment is slightly convex and sparsely pubescent. Mostly membranous, it has a wide subanal plate (pbs) in its dorsal area and a smaller one at the base of each seta. The anus occupies the bottom of a transverse slit dividing the tip of the abdomen into a suranal lobe and a subanal lobe. The dorsal wall of this opening is partially sclerified and densely setiferous. The

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PLATE II

MATURE LARVA:

Fig. 11—Labrum, anterior aspect.
Fig. 12—Left mandible, postero-ventral aspect.
Fig. 13—Right mandible, postero-ventral aspect.
Fig. 14—Right maxilla, postero-ventral aspect.
Fig. 15—Labium and maxillae, postero-ventral aspect.
Fig. 16—Antenna.
Fig. 17—Thoracic leg, lateral aspect.
Fig. 18—Subanal appendage.

Abbreviations

ap—apodeme; cd—cardo; cx—coxa; fm—femur; gl—galea; lc—lacinia; m—mentum; pfr—palpifer; pl—labial palpus; pmx—maxillary palpus; ser—sericos; sgl—subgalea; sm—submentum; st—stipes; sti—stipulae; ta—tarsus; tb—tibia; tog—totaglossa; tr—trochanter.

ventral wall, which is more or less sclerified, has a few scattered setae and it is fused below with the subanal plate. The subanal lobe has a pair of three segmented setiform appendages (asb) (Fig. 18) located on each side, just below the lateral ends of the anal slit. The first and second articles are sparsely setiferous, while the distal one is glabrous. The relative length of these articles often serves for the determination of species. In *C. marginata*, the first article is almost as long as the two others together, and the third is a little shorter than the second.

Morphology of the Adult

Middlekauff (1953) has published a general taxonomic description of both sexes of *C. marginata;* the present study involves only the morphological aspects.

Fig. 19

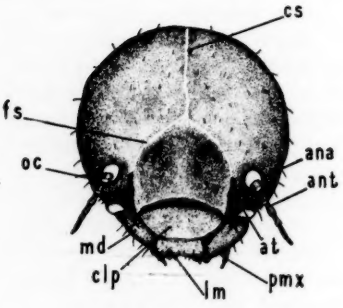

Fig. 20

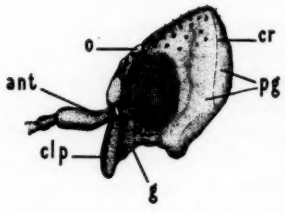

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Fig. 21

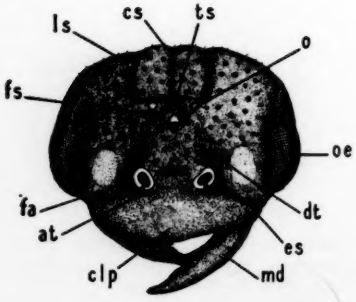
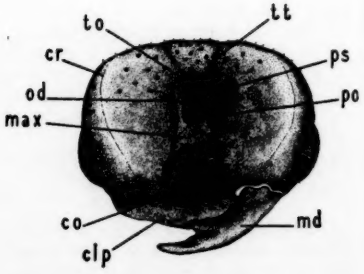


Fig. 22



Head and Appendages

The head is of the "closed head" type. The ventral parts of the maxillariae are joined on the meson, forming a broad bridge between the postgenae and separating the occipital foramen from the oral cavity. The clypeus is folded under the ventral part of the head, and the postgenae are produced mesoventrally and fused to the lateral areas of this sclerite. The cephalic capsule, therefore, has only three small openings in its wall through which the mouthparts protrude: two small lateral holes receiving the mandibles, and a larger median one representing the oral cavity and receiving the labium and the maxillae.

From the anterior aspect (Fig. 21), the head has a subcircular contour. The compound eyes (oe) are small, bean-shaped and fixed to the latero-ventral portion of the head. The antennae are attached between the eyes. The epicranial suture is incomplete: the coronal suture (cs) is always visible but its arms, the frontal sutures (fs), are short and inconspicuous, ending midway between the median and lateral ocelli (o). Consequently, the boundaries of the front are not distinct. The postocellar area, on the contrary, is well defined by lateral sutures (ls) diverging towards the front so that if continued forward they should pass outside the antennal socket (fa). These sutures are connected by a more or less distinct transverse suture just dorsad of the lateral ocelli. Since the clypeus (clp) is folded under the ventral portion of the head, it would seem divided into a postclypeus and a preclypeus; yet there is no suture between these two regions. It is separated from the front by a transverse furrow between the base of the antennae and it is also detached from the genae by an oblique lateral suture (es) extending dorsad into an elongate depression which represents the anterior tentorial invagination (at). Two other similar depressions dorsad of the antennal sockets mark the attachment of the supratentoria and represent the dorsal tentorial invaginations (dt). The antennal sclerite is a thickening of the socket margin on the ventral part of which a distinct tooth-shaped antacoila articulates with the antenna. On the posterior face of the head (Fig. 22), the postoccipital suture (ps) marks the dorsal and lateral boundaries of the postocciput (po) and separates it from the occiput dorsally and from the postgenae (pg) laterally. Two diverging furrows at the top of the occiput line the course of the tentorial thickenings (tt). Laterally (Fig. 20), the postgenae are divided into two parts by a distinct ridge or crassa (cr) that originates at the posterior articulation of the mandible and runs dorsad, almost completely encircling the postoccipital area. The postocciput is the narrow strip surrounding the occipital foramen (to). Each side of this opening, a small triangular projection, the odontoidea (od), articulates with the cervical sclerites. These projections mark

PLATE III

MATURE LARVA:

Fig. 19—Head anterior aspect.

ADULT:

Fig. 20—Head, lateral aspect.

Fig. 21—Head, anterior aspect.

Fig. 22—Head, posterior aspect.

Abbreviations

ana—antennaria; ant—antenna; at—anterior tentorial invagination; clp—clypeus; co—oral cavity; cr—crassa; cs—coronal suture; dt—dorsal tentorial invagination; es—epistomal suture; fa—antennal socket; fs—frontal suture; g—gena; lm—labrum; ls—lateral suture; max—maxillaria; md—mandible; o—ocellus; oc—ocularium; od—odontoidea; oe—compound eye; pg—postgena; pmx—maxillary palpus; po—postocciput; ps—postoccipital suture; to—occipital foramen; ts—transverse suture; tt—tentorial thickenings.

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the dorsal boundaries of the maxillariae (max) that also extend ventrad into two small divergent points articulating with the maxillae. Attached to the ventral margin of the oral cavity (co), the labrum (Fig. 24) is not visible externally. This is a flattened lobe terminating into a slightly asymmetrical point. This point is membranous, but the basal part of the labrum is sclerified and microscopically setiferous.

The mouthparts are directed downward when at rest. Similar in shape, the left and right mandibles (Figs. 25 and 26) are long and somewhat sickle-shaped. Strongly sclerified, each one has a big blunted tooth and bears on its

Fig. 23

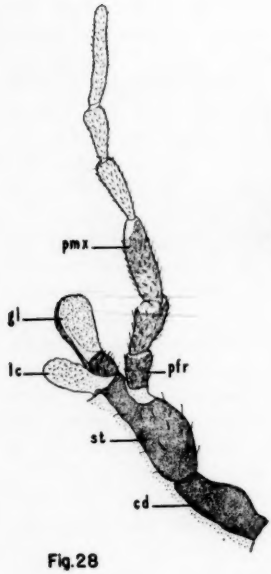


Fig. 24

Fig. 25

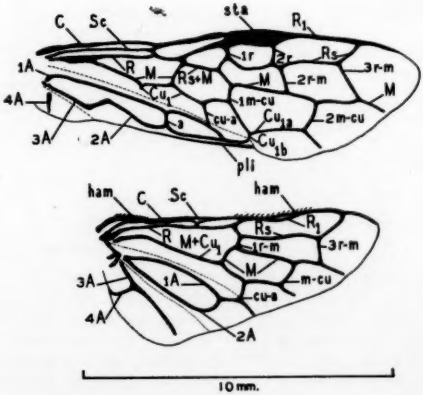
Fig. 26

Fig. 27

Fig. 28

1mm.

Fig. 29



outer face a row of long bristles. The maxilla (Fig. 23) is undivided and the elongate cardo (cd) is sclerified, glabrous and articulates at its base with the maxillariae. The stipes (st) is also undivided, but it is very convex laterally and sparsely pubescent. At the end of the stipes, a small membranous lobe extending toward the labium constitutes the lacinia (lc). An additional somewhat larger lobe projects also at the end of the stipes; this is the galea (gl). It is pubescent and partially membranous on its outer face. The maxillary palpus (pmx), relatively long and stout, is composed of 6 articles, the first one representing the palpifer (pfr). In the labium (Fig. 28), the submentum (sm) is entirely membranous and its position is indicated only by a row of hairs, whereas the mentum appears to be wanting. A large and convex setiferous plate forming the main parts of the labium represents the stipulae (sti). Its posterior margin is round, but its anterior border is cut off by 3 notches forming two blunt teeth ventrally and two lateral points around the base of the labial palpi (pl). These short palpi are made of 4 articles, the first of which is the palpiger (pgr). It presents on its ventral face a longitudinal suture probably indicating a support line. At the tip of the labium, the glossae are fused on the meson to form the alaglossa (alg). This is an elongate lobe, membranous underneath but sclerified laterally. There are two other small membranous lobes, the paraglossae (pgl), lying each side of the alaglossa. The alaglossa and the paraglossa are densely setiferous on their ventral surface.

The antennae (Fig. 27) are filiform in both sexes, setiferous and composed of 23 to 25 articles. The third antennal segment is a little longer than the fourth and fifth together. It is slightly lobed and apparently made up of four fused primary segments, as was suggested by Benson (1945).

Thorax and Appendages

Joining the head to the thorax (Figs. 30, 31 and 32) are two enlarged cervical sclerites (cv) to which are fused the reduced propleura. These plates are inclined anteriorly and terminate into round adjacent points. Postero-ventrally, they are convex and enlarged, and become close to one another on the meson. The pronotum (pn) is a narrow collar on the dorsum, but much enlarged on the sides, its caudal border extending to form a dorsal round point. It is grooved by a transverse furrow near its anterior margin. The prosternum is much reduced and is composed of two small sclerites widely separated in a membranous area: the probasisternum (ps) and the spinasternum (ss). The former is located between the first pair of legs, just behind the cervical sclerites.

PLATE IV

ADULT:

Fig. 23—Left maxilla, postero-ventral aspect.
Fig. 24—Labrum, ventral aspect.
Fig. 25—Left mandible, anterior aspect.
Fig. 26—Right mandible, anterior aspect.
Fig. 27—Antenna.
Fig. 28—Labium, postero-ventral aspect.
Fig. 29—Anterior and posterior wings.

Abbreviations

A—anal vein; a—anal cross-vein; alg—alaglossa; C—costa; cd—cardo; Cu—Cucubitus; cu-a—cubito-anal cross-vein; Cula—branch of first cubitus; Culb—branch of first cubitus; fu—flagellum; gl—galea; ham—hamuli; lc—lacinia; M—media; m-cu—medio-cubital cross-vein; pfr—palpifer; pgl—paraglossa; pgr—palpiger; pl—labial palpus; pli—coupling fold. pmx—maxillary palpus; R—radius; r—radial cross-vein; r-m—radio-medial cross vein; Rs—radial sector; Sc—subcosta; sc—scape; st—stipes; sta—stigma; sti—stipulae.

Ogival anteriorly, it broadens posteriorly forming two small lateral crescents. A median longitudinal suture divides it into two similar parts. The spinasternum constitutes a minute triangular sclerite just in front of the mesosternum.

The mesothorax is dorsally divided into 4 principal parts: the prescutum (prs), the scutum (scut), the scutellum (scl) and the postnotum (ptn). The

Fig. 30

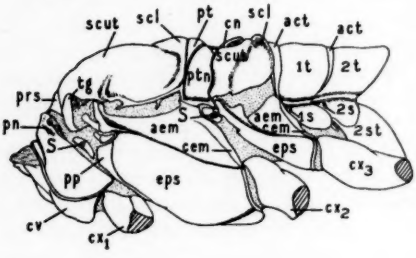


Fig. 31

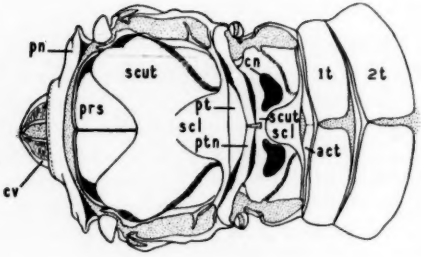


Fig. 32

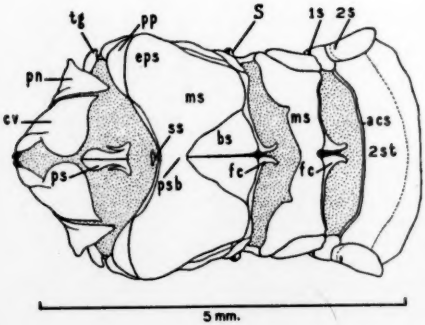


Fig. 33

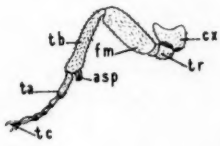


Fig. 34

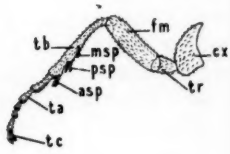


Fig. 35

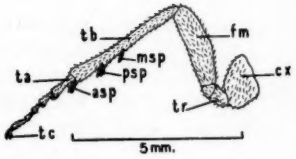


Fig. 36

Fig. 37

Fig. 38

triangular prescutum in front, with its apex directed backward, is also divided into lateral halves. The median scutum is very large and covers a great portion of the mesonotum. It has no transverse division, but two oblique furrows cut out in its postero-lateral parts the slanting parascutellar areas. The scutellum is elevated and fused in the front with the scutum, but its posterior margins extend laterally to form the axillary cords of the fore wings. The post-tergite (pt) is separated from its posterior part by a transverse furrow. The postnotum, a narrow collar, is partially folded underneath the scutum of the metathorax and forms the lateral postalar bridges. The mesothoracic spiracle (S_2) is located in the intersegmental membrane cephalad of the prepectus (pp), that marginal sclerite in front of the episternum (eps). A long and hollow suture divides obliquely the mesopleuron into an epimeron and an episternum. This first sclerite is partially subdivided into a narrow katepimeron (cem) and a much larger triangular anepimeron (aem). Very convex, the episternum (eps) runs ventrad and is fused with the sternum to form a large presternal bridge. A triangular sclerite, the basisternum (bs), extends behind this bridge and is grooved on the meson by a longitudinal depression. Two narrow sclerites, the furcasternites (fc), form the posterior border of the mesosternum and extend backward between the mesothoracic legs. The metathorax is much shorter than the mesothorax, but its structure is quite similar. However, the prescutum appears to be wanting and the scutum carries a pair of membranous pads, the cenchri (cn). In addition, the scutellum is completely detached from the scutum and constituted of a single piece. The prepectus is wanting but the epimeral suture is complete in its entire length. The basisternum has disappeared or at least is fused with the furcasternites.

As for the legs (Figs. 33, 34 and 35), a certain number of spurs present on the ventral face of each tibia offer very useful characteristics for the classification of the different Pamphiliidae species. In *C. marginata*, these spurs are not entirely sclerified, but terminate into a membranous tubercle. There are 2 apical spurs (asp) on each tibia, while the second and third pairs of legs have, in addition, 2 pre-apical spurs (psp) and a median one (msp). The apical spur on the median and hind tibiae (Fig. 38) have the same shape, although one might be smaller than the other; however, on the front tibia, one of the spurs (Fig. 36) is bifid at the apex and somewhat larger. The tarsal segments are deeply excised from the apex on the underside, and on the basitarsus this excision (Fig. 38) is

PLATE V

Fig. 30—Thorax, lateral aspect.
Fig. 31—Thorax, dorsal aspect.
Fig. 32—Thorax, ventral aspect.
Fig. 33—Front leg, anterior aspect.
Fig. 34—Median leg, anterior aspect.
Fig. 35—Hind leg, anterior aspect.
Fig. 36—Apical spurs of front tibia, lateral aspect.
Fig. 37—Hind metatarsus, ventral aspect.
Fig. 38—Hind basitarsus, ventral aspect.

Abbreviations

acs—acrosternite; act—acrotergite; aem—anepimeron; ar—arolium; asp—apical spur; bs—basisternum; cem—katepimeron; cn—cenchrus; cv—cervical sclerite; cx—coxa; eps—episternum; fc—furcasternite; fm—femur; ms—mediosternite; msp—median spur; pn—pronotum; pp—prepectus; prs—prescutum; ps—probasisternum; psb—presternal bridge; psp—pre-apical spur; pt—post-tergite; ptn—postnotum; S—thoracic spiracle; s—abdominal spiracle; ss—spinasternum; ta—tarsus; tb—tibia; tc—tarsal claw; tg—tegula; tr—trochanter; 2st—2nd abdominal sternite; 1t—1st abdominal tergite; 2t—2nd abdominal tergite.

continued as a suture to near the base. Thus the pulvilli cover a large part of their respective segments. The tarsal claws (Fig. 37) are sharply pointed and bear on their inner margin a very small median tooth.

The wings (Fig. 29) are well developed and exceed the tip of the abdomen when at rest. They are hyaline with dark brown veins and have an irregularly embossed surface chiefly at the apex. On the fore wing, a narrow infuscated band crosses obliquely in the region of the stigma (sta). The hind wing bears on its anterior margin 2 series of crochets or hamuli (ham). Since the complete venation of the wings is illustrated (Fig. 29), individual description of the

Fig. 39

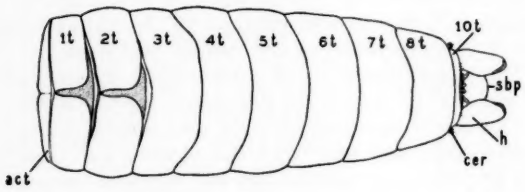


Fig. 40

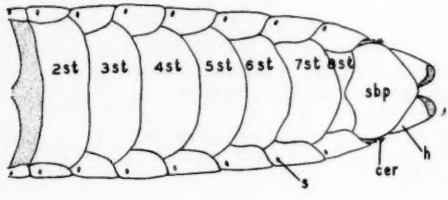
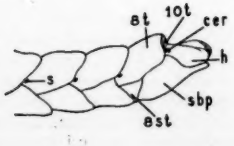


Fig. 41



5 mm.

Fig. 42

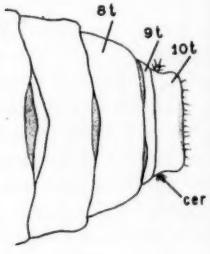


Fig. 43

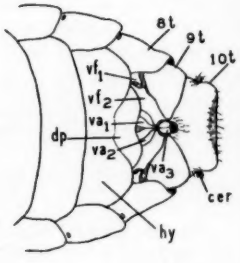
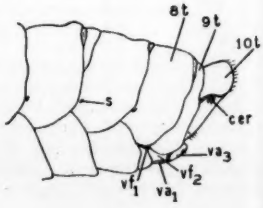


Fig. 44



veins will be omitted. In the fore wing, the subcosta (Sc) is free on its entire length and is divided at the tip into 2 branches (Sc_1 and Sc_2). As the media (M) is fused with the radial sector (Rs) at the base of this vein, there is no first radio-medial cross-vein (lr-m). The base of the first cubitus (Cu_1) is obsolete, while the second cubitus (Cu_2) is absent. In addition, the second radio-medial cross-vein (2r-m) is obsolete near its junction with the media and it is entirely atrophied in the hind wing.

Abdomen and Genital Armatures

In both sexes, the abdomen is flattened with acute lateral margins. It is wider and a little more convex ventrally in the female. Largely joined to the thorax, the first abdominal segment is sclerified dorsally and laterally, but quite membranous ventrally. The first and second tergites are divided mesally by membranous notches which form two pairs of lateral plates (Figs. 39 and 40). The next five segments are entire and nearly identical in shape. The tergites of the first eight segments are folded in ventrad on the sides where a pair of spiracles (s) is present. There are several modifications in the caudal segments. In the male, the tergite of the eighth segment is normal (Figs. 40 and 41), but its sternite is narrow and deeply emarginated at its posterior edge. The contrary occurs on the ninth segment (Fig. 45), the tergite being very narrow and entirely concealed under the preceding segment, whereas the sternite is considerably developed (Fig. 46) to form the subgenital plate (sbp). The tenth segment consists only of a narrow tergite which bears on each side a short membranous appendage, the cercus (cer). In the female, the modifications begin with the seventh segment (Fig. 43). The seventh sternite, which is slightly enlarged to form the hypopygium (hy), is cut on its posterior margin by a large and triangular apical impression (dp). The eighth and ninth tergites are normally developed, but their ventral parts are modified to form the genital armatures. At the tip of the abdomen, the tenth segment is complete, convex on the dorsum but abruptly inclined on the venter. Its apical border is membranous and densely setiferous.

The male genitalia (Figs. 47 and 48) form a well-organized capsule which, while at rest, is partially retracted within the apical abdominal segments to which it is attached by a flexible membranous tube. For more uniformity in the terminology applied to its various parts, we have adopted the terms suggested by Ross (1945). The male genital organs of *C. marginata* retain their primitive position, that is, they are oriented as in the pupa, contrary to what occurs in the majority of other sawflies. The genital capsule is composed of 4 principal parts: a gonocardo (gc), paired gonoforceps, paired volsellae (v) and a penis

PLATE VI

ADULT:

Fig. 39—Male abdomen, dorsal aspect.
Fig. 40—Male abdomen, ventral aspect.
Fig. 41—Male abdomen, lateral aspect.
Fig. 42—Tip of female abdomen, dorsal aspect.
Fig. 43—Tip of female abdomen, ventral aspect.
Fig. 44—Tip of female abdomen, lateral aspect.

Abbreviations

act—acrotergite; cer—cercus; dp—apical impression; h—harpes; hy-hypopygium; s—abdominal spiracle; sbp—subgenital plate; vs—valva; vf—valvifer; 2st, etc.—2nd, etc. abdominal sternite; 1t, etc.—1st, etc., abdominal tergite.

(ps). The gonocardo has the shape of a very narrow ring surrounding the base of the capsule to which it is connected by a circular membrane. Arising above the gonocardo are a pair of lateral clasper-like appendages, each being a gonoforceps subdivided into a basal portion or gonostipes (gs) and a distal articulated portion, the harpes (h). On the ventral side, the gonostipes cover only the lateral parts of the capsule and they are connected at the base by a narrow strip extending towards the center, while they cover nearly all its dorsal

Fig. 45

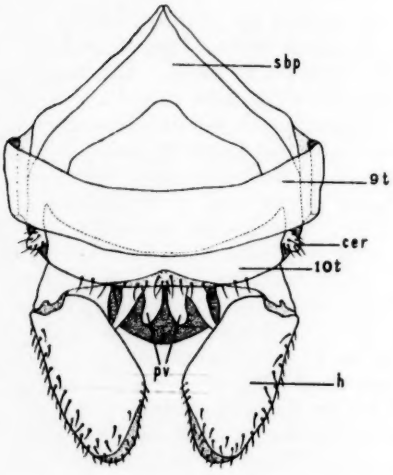


Fig. 46

Fig. 47

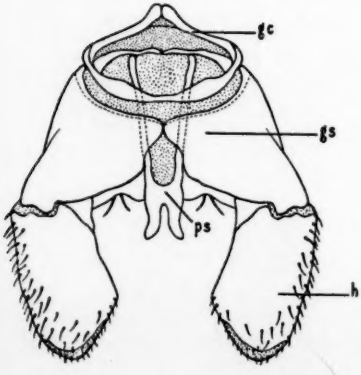
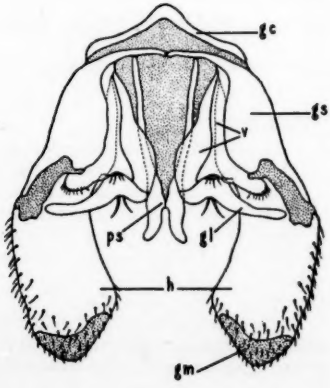


Fig. 48



surface. At their distal end, the harpes have a membranous suction organ, the gonomacula (gm). The volsellae are located in the ventral part of the capsule and are widely separated mesally but intimately joined to the gonostipes laterally. Each volsella (Fig. 52) is composed of a large flattened portion contigous with the membranous edge of the gonositipes, the basivolsella (bv), and of an apical portion divided into 2 definite lobes projecting beyond the gonostipes: a lateral distivolsella (dv) which is a continuation of the basivolsella, and a mesal gonolacinia (gl) articulating with the posterior edge of the basivolsella. This latter piece has a longitudinal thickening the apex of which marks the articulation point of the gonlacinia which is composed of a basal portion or basiura (ba) and of a lateral digitiform prolongation, the apiceps (ap). The median structure, which is the penis (Figs. 49, 50 and 51), is divided into a pair of elongate lateral plates, the penis valves (pv), which are hinged at their apex by a membrane along the dorsal surface. Each valve is composed of an apical lobe, the valviceps (vc), and of a basal tail-like portion, the valvura (vr), which is attached to the capsule by both muscles and membrane. On the outer side of the valviceps is a short lateral ergot for muscle attachment.

In *C. marginata* female, the ovipositor is not much developed, but it includes all the functional units of a typical sawfly ovipository apparatus. It consists of two pairs of valvifers (vf) attached ventrally to the ninth tergite and giving rise to the other parts: three pairs of valvae (va), the two first ones (va_1 and va_2) forming the saw, and the third (va_3) forming the sheath. Rather simple in structure, the sheath (Fig. 54) consists of two convex halves partially membranous and attached to the posterior end of the second valvifer. The second valvifer and the sheath together constitute a protective case within which the saw is retracted when not in use. The saw is much more complex and composed of two pairs of articulate appendages, the pair of dorsal blades or lances (Fig. 54) born on the second valvifers, and the pair of ventral blades or lancets (Fig. 55) arising from the first valvifers. The lances are fused along the dorsum to form a hood-shaped structure (Fig. 53). Their apical portion or lamnium (la) is divided into 8 segments by transverse seam-like sutures, but their basal portion or radix (ra) is entire and bears the articulation with the valvifer to which it is joined by its ventro-lateral branch (rva_2). Each lancet has a long membranous radix bearing a dorsal sclerified branch (rva_1) and a ventral tractium (tr) also sclerified and enlarged anteriorly into a heel-shaped tangium (ta). Its lamnium is distinctly divided into 9 segments and is strengthened underneath by a strongly sclerified strip or sclerora (so). The ventral margin of each segment forms a concave undentate serrula (se), and the transverse sutures bear a wing-shaped lateral projection, the ala (a).

Acknowledgements

The author wishes to acknowledge the helpful advice and guidance of Dr. L. Daviault, Officer-in-Charge, Laboratory of Forest Biology, Science Service,

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PLATE VII

ADULT:

Fig. 45—Tip of male abdomen, dorsal aspect.
Fig. 46—Subgenital plate, ventral aspect.
Fig. 47—Male genitalia, dorsal aspect.
Fig. 48—Male genitalia, ventral aspect.

Abbreviations

cer—cercus; gc—gonocardo; gl—gonolacinia; gm—gonomacula; gs—gonostipes; h—harpes; ps—penis; pv—penis valve; sbp—subgenital plate; t—abdominal tergite; v—volsella.

Quebec, who suggested the writing of this paper and supplied the study material. Acknowledgment is gratefully extended to all members of the Provincial Agricultural Research Council, Department of Agriculture, Quebec, for the generous grant of a scholarship making possible the completion of this study. Many thanks are also due to A. B. Baird, Head, Biological Control Unit, Ottawa, and

Fig. 49

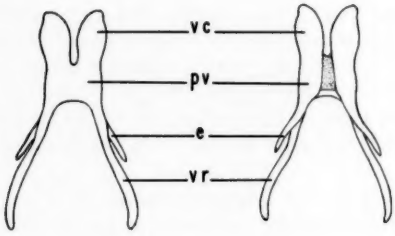

Fig. 50

Fig. 52

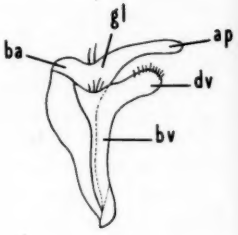

Fig. 51

Fig. 53

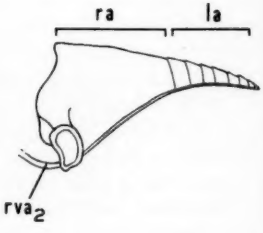

Fig. 54

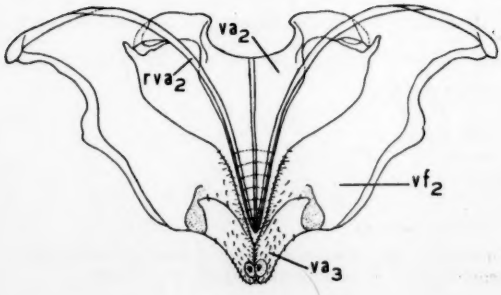

Fig. 55

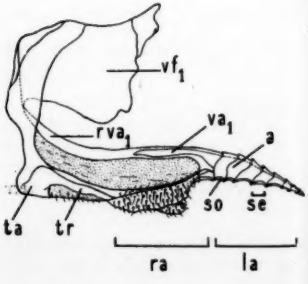

PLATE VIII

ADULT:

Fig. 49—Penis, dorsal aspect.
Fig. 50—Penis, ventral aspect.
Fig. 51—Penis, lateral aspect.
Fig. 52—Volsella, ventral aspect.
Fig. 53—Lances, lateral aspect.
Fig. 54—2nd and 3rd pairs of valvae, ventral aspect.
Fig. 55—Lancet, lateral aspect.

Abbreviations

a—ala; ap—apiceps; ba—basiura; bv—basivolsella; dv—distivolsella; e—ergot; gl—gonolacinia; la—lamnium; pv—penis valve; ra—radix; rva—valva branch; se—serrula; so—sclerora; ta—tangium; tr—tractium; va—valva; vc—valviceps; vf—valvifer; vr—valvura.

L. J. Briand, Officer-in-Charge, Biological Control Section, Entomology Laboratory, Quebec, for their very helpful criticisms of the manuscript.

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Abundance and Relative Importance of Caterpillars Attacking Cabbage in Eastern Ontario[1]

By D. G. HARCOURT[2], R. H. BACKS[3], AND L. M. CASS[4]
Vegetable Insect Section, Entomology Laboratory
Ottawa, Canada

Cabbage and related crops are attacked every year throughout Ontario by caterpillars of three species, namely, the imported cabbageworm, *Pieris rapae* (L.), the diamondback moth, *Plutella maculipennis* (Curt.), and the cabbage looper, *Trichoplusia ni* (Hbn.). The imported cabbageworm is generally regarded as the most abundant of the three species and is reported as doing damage of considerable economic importance each year. The cabbage looper does not occur in large numbers until late in the season, but in most years it is believed to be second only in importance to the imported cabbageworm. The diamondback moth is generally considered to be much less important than the other two species (Caesar, 1938). As previously reported (Matthewman *et al.*, 1952), these beliefs were not borne out by observations of field populations at Ottawa in 1950. Whereas populations of the cabbage looper were strikingly low, those of the diamondback moth were much higher than the literature indicated. This paper is a summary of four seasons' experiments, 1951-1954, undertaken to assess the abundance and relative importance of the three species in eastern Ontario.

Abundance

Methods

The study plots were at Merivale, Ontario, five miles south of the Central Experimental Farm, Ottawa. Although the experimental work was confined to this area, numerous observations were made throughout eastern Ontario during the investigation. Frequent spot checks indicated that populations of caterpillars on cabbage at Ottawa are representative of the larger area. Furthermore, they appear to be representative of lepidopterous populations on cauliflower, broccoli, brussels sprouts, collards, kohlrabi, and kale.

In eastern Ontario, cabbage is usually transplanted from the seedbed to the field in two periods. The early crop, which is for summer use, is planted in late May; the late crop, which is for fall and winter consumption, is planted in late June. The early crop matures in July and is harvested from about the middle of July. The late crop, which matures in October, is cut at intervals throughout October.

The first phase of the work was an analysis of the complex of lepidopterous species attacking early and late cabbage. The experimental crops, of Golden Acre and Penn State Ballhead, respectively, were grown in adjacent quarter-acre fields. Commercial practice was followed throughout the experiment, plants of the early crop being set out during the last two weeks of May and those of the late crop during the last 10 days of June. Each crop was examined weekly from the time it became established until the close of harvest, work on the two crops overlapping for two or three weeks each season. On the average, there were 9 weekly examinations of the early crop, 16 of the late. Although all of the immature stages of the species were recorded each season, only the data pertaining

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2Associate Entomologist.

3Assistant Entomologist.

4Technician.

to larval populations are presented here because they are typical of the population as a whole.

The plants were dissected and examined leaf by leaf. In most previously reported studies of this type reported by other authors (Harrison and Brubaker, 1943; Reid and Bare, 1952) the plants were left intact during examination; however, preliminary work at Ottawa showed that records in which the plants are not dissected are unsatisfactory for population studies that include the diamondback moth. At the slightest disturbance of the plants, larvae of this species spin threads and often drop to parts of the plant where they may be overlooked. In addition, the first-instar larvae, which characteristically mine the leaf, are easily missed unless individual leaves are examined closely.

Forty-nine plants of each crop were examined each week—an average of 450 plants each season for the early cabbage and 800 for the late. To obtain representative samples of field populations each field was marked off by means of a 7 x 7 grid into 49 plots of equal size. At the first sampling a single plant was chosen at random from each of the plots; thereafter successive samples were chosen systematically in relation to the first selection (Harcourt, 1954).

Results and Discussion

Early Cabbage.—On the early crop the imported cabbageworm was the most abundant species; of 16,605 larvae recorded during the four-year period, approximately three-fifths were of this species (Table I). Although present in decidedly fewer numbers than the imported cabbageworm in two of four seasons, larvae of the diamondback moth were slightly more numerous in a third season, distinctly more numerous in a fourth. The cabbage looper was almost negligible on the early crop. The three species did sufficient feeding each year to render the majority of the cabbage heads unsaleable. On the average, less than 10 per cent of the heads were in marketable condition by the end of the third week of July.

Except for a slight lull between the first and second generations, the imported cabbageworm was the most abundant species throughout the crop season (Fig. 1). The insect was present in the field almost from the date of planting, but did not

TABLE I

Percentages of larvae of lepidopterous species attacking early and late cabbage, Ottawa, Ontario, 1951 — 1954

Year	Early cabbage				Late cabbage			
	Total number of larvae	Percentage of total			Total number of larvae	Percentage of total		
		Imported cabbage-worm	Diamond-back moth	Cabbage looper		Imported cabbage-worm	Diamond-back moth	Cabbage looper
1951	3,794	89.6	9.7	0.7	15,231	41.2	58.6	0.2
1952	6,466	83.2	16.1	0.7	13,831	45.7	51.1	3.2
1953	3,280	43.1	55.1	1.8	20,100	17.8	78.7	3.5
1954	3,065	20.7	78.7	0.6	24,424	12.4	86.6	1.0
Mean		59.1	39.9	1.0		29.3	68.7	2.0

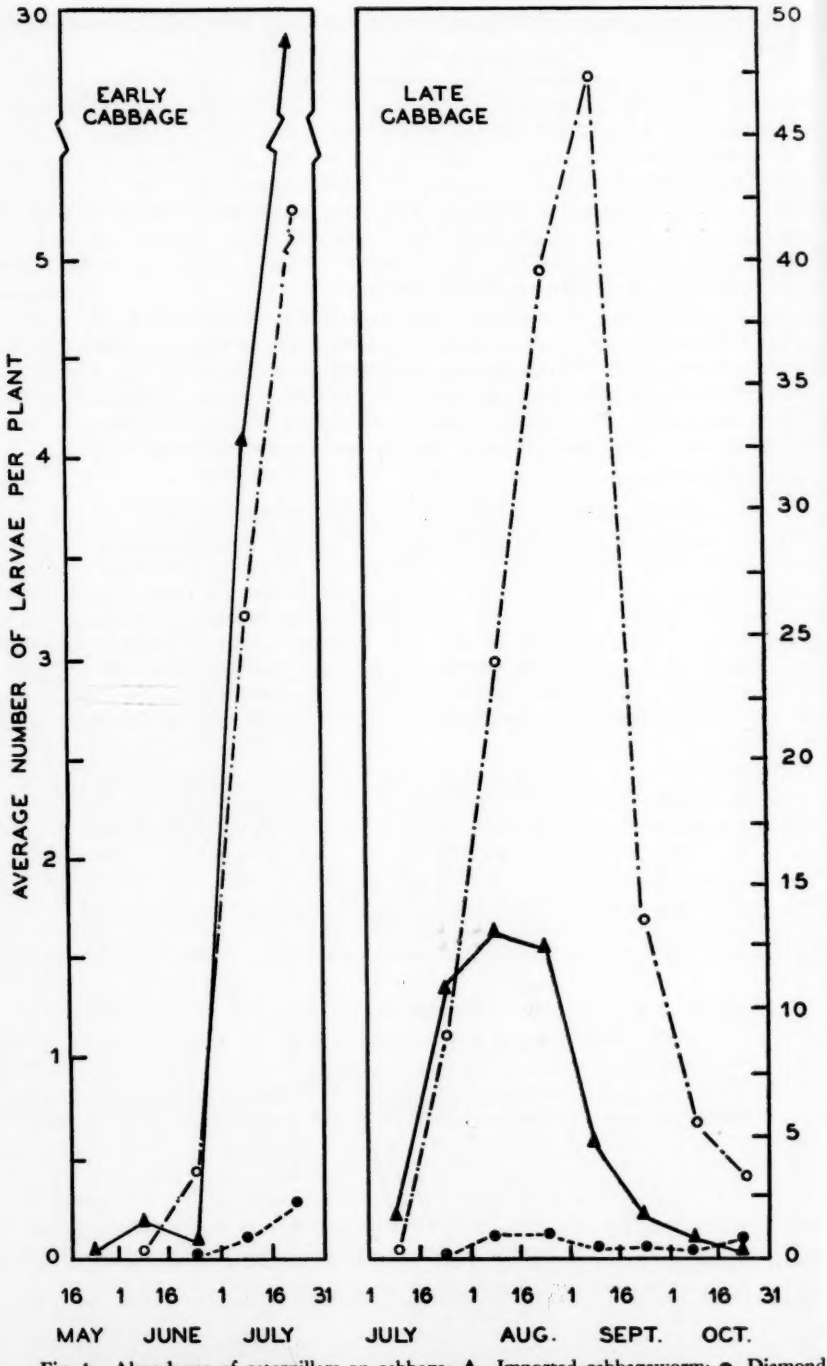

Fig. 1. Abundance of caterpillars on cabbage; ▲, Imported cabbageworm; o, Diamond-back moth; ●, Cabbage looper; Ottawa, Ontario, 1951-1954.

reach significant numbers until the first week of July, when the peak of oviposition for the second generation normally occurred. By the end of the harvest period, there was an average population of 26.9 larvae per plant.

Larvae of the diamondback moth were rarely observed in the experimental fields before mid June. The peak of egg-laying usually occurred during the second week of July. The population built up rapidly during July, reaching an average of 14.9 larvae per plant by the close of harvest.

Late Cabbage.—On the late crop, the diamondback moth was the most numerous species each season; of 73,586 larvae recorded during the four-year period, approximately two-thirds were of this species (Table I). The imported cabbageworm was slightly less than half as plentiful. Again, the cabbage looper did not form a significant portion of the species complex. Each season, more than 75 per cent of the heads in the field were unmarketable by late October.

The imported cabbageworm was the most abundant species until the last week of July (Fig. 1), the population beginning to decline during early August. This, in part, coincided with pupation of larvae of the second generation, but owing to an outbreak of a highly contagious larval disease each year the population did not build up again. Infected individuals turned a muddy-grey colour; later the body contents blackened, and the larvae collapsed into a rotting mass. These symptoms strongly resemble those of flacherie (Twinn, 1924; Wilson *et al.*, 1919).

The population increase of larvae of the diamondback moth occurred simultaneously with that on the early crop, and by early September a peak population of 47.1 larvae per plant occurred. From this point, the population declined steadily due to cool weather and parasitism, chiefly by the ichneumonids *Diadromus plutellae* (Ashm.) and *Horogenes* sp. near *plutellae* (Vier.).

There was a definite association between populations on the early and late crops during July. Each season, oviposition of both the imported cabbageworm and the diamondback moth increased sharply during the first half of the month and then decreased slowly. Both species showed a decided preference for the larger, early cabbage until this date, when a distinct cross-over occurred. This was due to the increased competition afforded by the rapidly growing late crop; for example, in 1952, growth records obtained on July 17 and July 23 showed that during this period the late cabbage more than doubled in size. The larval populations also built up rapidly during July, the upward trend continuing into August.

Relative Importance

Methods

The foregoing studies established the relative abundance of caterpillars of the three species. However, this does not establish the relative importance of the species, for there is a difference in the amount of feeding done by individuals of each. Accordingly, the following laboratory experiment was conducted in 1953.

On July 28 and again on August 25, 25 eggs of each species were collected at random in the field and brought into the laboratory. The eggs and the small portions of leaf supporting them were immediately placed in petri dishes. Upon hatching, the larvae were individually reared to maturity in 115-mm. stacking dishes, each containing a freshly cut, three-inch disc of cabbage leaf. Beneath each disc was placed a single filter paper; this was kept moist to maintain the freshness of the leaf. The leaf discs were changed every second day, the criterion of foliage consumption being the original weight of the fresh leaf disc

less its ultimate weight, measured in milligrams. To obtain a correction factor compensating for loss in leaf weight due to desiccation, a large series of check leaves was also observed. The ratio of food intake was calculated by dividing the food intake of the diamondback moth into that of the other two species.

Results and Discussion

The food intake of the three species in the laboratory at a mean temperature of 73°F. was as follows:—

	Average length of feeding period, days	Average amount of leaf ingested, mg.	Ratio of food intake
Diamondback moth	8.8	87.7	1.0
Imported cabbageworm	13.3	1099.4	12.5
Cabbage looper	15.1	1688.4	19.3

In comparing the feeding done by individuals of two or more insect species during any one year in a given area, the number of generations of each for that area must be taken into account. The correct feeding ratio is then as follows:—

	Diamondback moth	Imported cabbageworm	Cabbage looper
Relative amount of food ingested	1	12.5	19.3
Mean number of yearly generations, Ottawa	5	3	3
Product	5	37.5	57.9
Feeding ratio	1	7.5	11.6

The percentages of the total consumption attributable to the three species are shown in Table II. The percentage of the total consumption was calculated by multiplying the number of larvae recorded by the feeding ratio, and considering the total consumption to be 100 per cent.

These data bring the relative importance of the species into sharper focus. They clearly demonstrate that, because the larvae of the imported cabbageworm consume more foliage per individual than do those of the diamondback moth, the imported cabbageworm must be regarded as the more important species on both crops. However, the amount of feeding done by larvae of the diamondback moth is by no means insignificant, and the insect is capable in some seasons, as for example in 1954 on late cabbage, of doing as much damage as the imported cabbageworm. The cabbage looper must be considered less important than the other two species.

General Discussion

The amount of foliage consumed is but one of the factors governing the relative importance of the three species. Other aspects of the problem requiring study are degree of gregariousness of the species, time of attack in relation to

TABLE II

Percentages of the total consumption of foliage attributable to the three species on the basis of larval populations and the feeding ratio, Ottawa, Ontario, 1951 — 1954

Year	Early cabbage			Late cabbage		
	Imported cabbageworm	Diamondback moth	Cabbage looper	Imported cabbageworm	Diamondback moth	Cabbage looper
1951	97.2	1.4	1.4	83.4	15.8	0.8
1952	96.3	2.5	1.2	79.3	11.9	8.5
1953	81.1	13.8	5.1	53.0	31.2	15.8
1954	64.8	32.9	2.3	48.5	45.3	6.2
Mean	84.8	12.7	2.5	66.1	26.1	7.8

plant growth, parts of the plants attacked, and effects of feeding on subsequent growth and development of the crop.

The diamondback moth has been greatly underrated as a pest of cruciferous crops in North America. In most economic literature the insect has been described as being much less numerous than other members of the complex of caterpillars on cabbage and related crops. However, many of these reports appear to be based on visual assessments of the populations rather than careful analyses of the species complex. Methods of record-taking and the small size of the diamondback moth in its early stages have resulted in a bias that favours the other two species. In addition, untreated check plots in fields treated with insecticides are often used as a guide to assessment of field populations in a given area. These do not give a true picture of the abundance of the three species; unpublished data at Ottawa indicate that the populations of check plots in such fields are significantly lower than those of adjacent, untreated areas; again, the diamondback moth is the species most affected.

Summary

An analysis of the complex of lepidopterous species attacking cabbage at Ottawa, 1951-1954, showed that the order of abundance on early cabbage was the imported cabbageworm, the diamondback moth, and the cabbage looper; on the late crop, the diamondback moth, the imported cabbageworm, and the cabbage looper. In general, the imported cabbageworm was the most abundant species during June and July, the diamondback moth in August, September, and October. The cabbage looper at no time formed a significant portion of the species complex on either crop.

Laboratory studies on larvae of the three species indicated that the feeding ratio of equal populations of the diamondback moth, the imported cabbageworm, and the cabbage looper is: 1: 7.5: 11.6. The percentages of the total consumption of foliage attributable to the three species in the above order for the four seasons averaged as follows: early cabbage: 13, 85, and 2; late cabbage: 26, 66, and 8.

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A Record of an External Egg Parasite from Trinidad, B.W.I.

By FRED D. BENNETT
Commonwealth Institute of Biological Control

Wilted stems of *Eupatorium odoratum* L., (Compositae) in Trinidad were found to contain an egg or larva of a Curculionid. Each egg was deposited in a slit between two rows of punctures encircling the stem. This girdling made by the ovipositing female was obviously the cause of the wilting. Larvae hatching from the eggs fed for a few days in the wilted portion of the stem and then tunnelled into the sound tissue below the punctures completing development a month later, and pupating in the stem near the base of the plant. The adults, which emerged ten days later, were identified as *Rhodobaenus* sp. nr. *cariniventris* by Mr. R. E. Warner of the U.S. National Museum.

Two of the eggs examined each had a single minute hymenopterous larva on them. These larvae were feeding on the egg contents through punctures in the chorion. They completed development and pupated on the fifth day after collection and adults emerged ten days later. Emergence from the plant was through the slits made by the ovipositing Curculionid. The parasites were identified as *Euderus* sp. (Eulophidae) by Dr. B. D. Burks (also of the U.S. National Museum) who stated (in litt.) that the only external egg parasites known to him were those parasitic in spider egg masses and cockroach oothecae.

It was thought worthwhile recording these observations since in Clausen (1940) there is only a single instance noted of an external egg parasite, that of *Sympiesis* sp. (Eulophidae) an ectoparasite of *Cimbex americana* Leach. This is based on observations by Cushman (1926).

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Mortalities of Males and Females of *Tribolium confusum* Duv. (Coleoptera: Tenebrionidae) Exposed to Residual Deposits of *p-p'*-DDT[1]

By S. R. Loschiavo[2]

Stored Product Insect Unit, Entomology Division
Ottawa, Canada

The usual criterion of insectidal effectiveness is the mortality suffered by test insects exposed to insecticides. Often, investigators disregard the sex ratio when selecting test insects for exposure. Demonstrated differences in susceptibility between male and female insects require evaluation of the sex ratio in studies on insecticidal effectiveness.

Sex differences in susceptibility to insecticides were demonstrated in *Musca domestica* L. (Barber and Schmitt, 1948; Harrison, 1951), *Periplaneta americana* (L.) (Woodbury, 1938; McGovran and Fales, 1942), and *Drosophila melanogaster* Mg. (Kerr, 1954). Salmond (1953) found that the mortality of *Calandra granaria* (L.) and *C. oryzae* (L.) exposed to hydrogen cyanide under reduced pressure was not influenced by their sex; he further reported on the work of Gough (1939), who found a sex difference in *Tribolium confusum* Duv., females being more susceptible than males to atmospheric fumigation with hydrogen cyanide. This is a report on the mortalities of male and female adults of *Tribolium confusum* of different ages when exposed to DDT residues at different temperatures.

Materials and Methods

The test insects were reared at a constant temperature of 32°C. and a relative humidity of 70 to 75 per cent. Males and females were separated in the pupal stage and kept in containers of culture medium consisting of 95 per cent second patent flour and five per cent wheat germ by weight. Test groups were removed as required and held without food for 24 hours before exposure (Crauford-Benson, 1938; Parkin and Green, 1943; Tattersfield and Potter, 1943).

Para-para'-DDT was prepared as a five per cent solution in benzene dyed with methylene blue. This solution was applied to sandblasted glass plates 10 cm. square at 1 ml. per 100 sq. cm., a fine crystalline deposit of dyed DDT remaining on the surfaces after evaporation of the solvent. The deposits were measured colorimetrically. Only the most uniformly distributed deposits were used.

Plastic rings 10 cm. in diameter and 2 cm. deep were placed on the plates to confine the insects to the treated areas during exposure, the insects having complete freedom of movement within the rings. Preliminary work showed no significant differences in mortality between moving and non-moving (anaesthetized) males or between moving and non-moving (anaesthetized) females.

In all tests males and females were exposed separately in groups of 50 each to five per cent *p-p'*-DDT residues, control groups being exposed on untreated plates. After exposure each group was carefully transferred to ventilated glass jars containing food medium and maintained at 32°C. and 70 to 75 per cent relative humidity.

Males and females six weeks old were exposed in four replicates for two hours at 32°C. Mortality was recorded eight times in the 90 hours after exposure.

Males and females in nine age-groups between 0 and 42 days were exposed in

[1]Contribution No. 3348, Entomology Division, Science Service, Department of Agriculture, Ottawa, Canada.

[2]Assistant Entomologist.

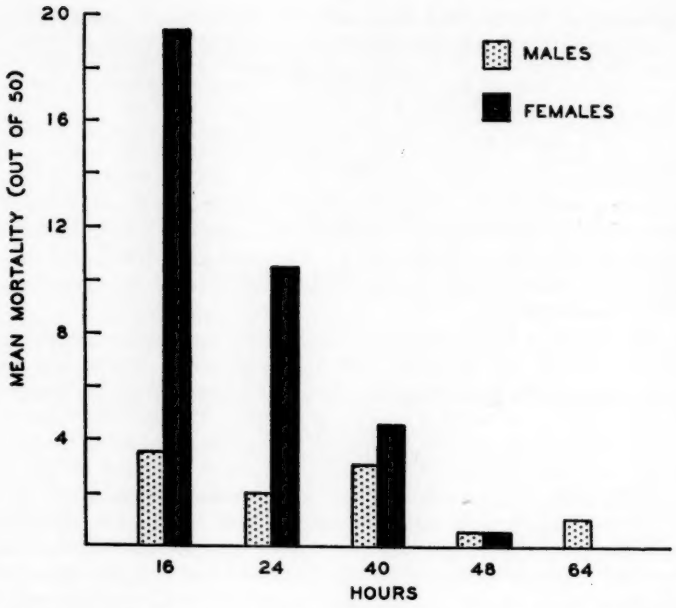

Fig. 1. Mean mortalities of males and females of *T. confusum*, 6 weeks old, from 0 to 90 hours after exposure to 5 per cent *p-p'*-DDT residues for 2 hours at 32°C.; mortality of males after 64 hours was 1 per cent.

duplicates for three hours at 32°C. Mortality was recorded four days after exposure.

Males and females one month old were exposed in duplicates for three hours at five temperatures from 16° to 32°. Mortalities were noted daily from the second to the seventh day after exposure.

Results and Discussion

Fig. 1 indicates that at 64 hours after exposure the mean mortality of females six weeks old was 3.5 times as great as that of males of the same age. At 16 and 48 hours, the mean mortalities of females were 39 and 70 per cent respectively, in comparison with 7 and 18 per cent for the males. No mortality occurred after 48 hours among females or after 90 hours among males; the mean mortality of males between 48 and 90 hours was three per cent.

Analysis of variance showed that adults 0 to 21 days old were significantly more variable in mortality than those of 21 to 42 days (Table I). In the older group the mortality of females was significantly higher than that of males.

Table II gives for males and females one month old the mortalities at two days and at seven days after exposure at five temperatures. The data at two days support the higher mortality shown in Fig. 1 for females than males at a relatively short time after exposure. Analysis of variance showed that the total mortality of females (for all temperatures) was significantly higher than that of males at two days and at seven days after treatment. Table II shows also that the combined mortalities of males and females at two days after exposure increased significantly between 16° and 32°C.

This study showed that under certain conditions of age and temperature female adults of *T. confusum* are more susceptible than males to DDT. The results clearly demonstrate the need for a knowledge of the sex ratio and age of experimental insects used in studies on insecticidal effectiveness.

TABLE I

Mortalities At 4 Days of Males and Females (50 of each) of *T. confusum* of Different Ages Exposed to 5 per cent *p–p'*—DDT Residues for 3 Hours at 32°C.

Age days	Males			Females			Mean difference between females and males†
	Test 1	Test 2	Difference[1]	Test 1	Test 2	Difference[1]	
0–1	7	14	7	10	42	32	15.5
2	32	8	24	45	8	37	6.5
3	23	22	1	23	19	4	−1.5
7	21	19	2	36	42	6	19.0
14	4	28	24	28	23	5	9.5
21	17	29	12	43	44	1	20.5
28	19	23	4	45	48	3	25.5
35	25	24	1	48	49	1	24.0
42	28	27	1	49	49	0	21.5

[1]The variance of the difference between the tests for the two sexes is 183 for beetles 0 to 14 days old and 10 for those 21 to 42 days old, the difference between the age groups being highly significant.

†Difference necessary from zero for significance at the one per cent level for beetles 0 to 14 days old, 43; for those 21 to 42 days old, 11.

TABLE II

Mortalities of Males and Females (100 of each) of *T. confusum*, 1 Month Old, at 2 and 7 Days After Exposure to 5 per cent *p–p'*—DDT Residues for 3 Hours at Different Temperatures

Temperature C°.	2 days after exposure			7 days after exposure		
	Males	Females	Total[3]	Males	Females	Total
16	3	32	35	66	85	151
22	17	81	98	89	100	189
25	25	83	108	72	98	170
27	56	93	149	88	98	186
32	56	96	152	66	96	162
Total	157[1]	385[1]		381[2]	477[2]	

[1]Difference necessary for significance at one per cent level, 47.
[2]Difference necessary for significance at one per cent level, 60.
[3]Difference necessary for significance at one per cent level, 31.

Gough (1939) reported that, under certain conditions, adults of *T. confusum* four to five weeks old emitted a self-toxic substance, virgin females producing more than virgin males. The present study was carried out under well-ventilated conditions and control groups showed no mortality. Therefore it is unlikely that self-toxicity contributed to the mortality of females. Age, sex, temperature, pretreatment of insects, uniformity of deposit, and movement were standardized or controlled. It appears, then, that some other factor or combination of factors is responsible for the difference in sex susceptibility.

A difference in sex susceptibility in *T. confusum* is important from the practical standpoint. Flour beetles are important economic pests of cereal products and measures that contribute to their control are welcome. If the difference in sex susceptibility occurs under practical conditions, control with DDT is greater than that indicated by mortality alone.

Summary

The mortality of adult females of *T. confusum* exposed to five per cent *p-p'*-DDT residues was significantly higher than that of exposed males. Adults less than three weeks old showed significantly greater variation in mortality than those three to six weeks old irrespective of sex. The rates of mortalities of males and females one month old increased with increasing temperature from 16° to 32°C.; however, at each of five temperatures within this range males died at a slower rate and in smaller numbers than females.

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(Received August 25, 1955)

Observations on the Mating Habits of *Dasymutilla formicalia* Rohwer (Hymenoptera: Mutillidae)[1]

By E. G. Linsley, J. W. MacSwain and Ray F. Smith
University of California, Berkeley

At a locality nine miles southwest of Fresnillo, Zacatecas, Mexico, a number of females of *Dasymutilla formicalia* Rohwer[2] and males of *D. pallida* Mickel[2] were observed around our campsite during the second week of August, 1954. However, all of the males and most of the females were active only in the early morning and late afternoon. On August 10th, in a dirt roadway about three-quarters of a mile from camp an unusually large concentration of these mutillids was discovered at about 6 p.m. Since but a single species of *Dasymutilla* appeared to be involved the following observations on the activities of the males and females were recorded.

Male activity consisted mainly of an irregular coursing flight an inch or two above the ground and into the prevailing east wind. After moving varying distances along the roadway they would fly rapidly back to the west end of the site at a height of a foot or more above the ground and again repeat the previous flight pattern. These flights were commonly interrupted to light on the ground near females. In all but one such case, the male approached the female, paused briefly to examine her, and then resumed the typical flight pattern. It appeared to the observers that in these instances the males had discovered the females by sight and encounters were as frequent with worn females as with those more freshly emerged. Furthermore, none of these encounters involved copulation. They were terminated by the males, the females being passive. In the hour during which these observations were made, thirty-one males were collected. These specimens were all later determined as *D. pallida* Mickel. Their pubescence varied from a bright red to a dull yellow color. They were assigned to arbitrary color categories as follows: seven red, thirteen reddish-orange, and eleven yellowish-orange, the latter with frayed wings. These data could be interpreted as indicating that males emerge over a considerable period of time and that individuals live for a number of days. It would also appear likely that males mate several times, the females only once.

Females were about as numerous as males and being somewhat easier to collect thirty-seven specimens were taken. This collection was made by crossing and recrossing the approximately one hundred yards of roadway many times and after watching each female for a brief period adding her to the collection. By this method it was apparent that individual females varied greatly in time of appearance, although this did not seem to be true of the males. The female activity consisted of moving rapidly over the ground and examining declevities in the surface or, more commonly, the earth around various small plants. This latter behaviour, which was similar to that of several species of parasitic epeoline bees, might indicate a host relationship with bees of the genus *Melissodes* which were observed to select this habitat for their burrows.

As was true of the males, the pubescence of the females varied strikingly in color. However, the variations in color in the females differed somewhat in that the bright red color of unworn and presumably fresh females apparently changes quite abruptly into a yellowish-orange and then somewhat less abruptly into a dull yellow. No attempt was made to determine the length of time

1The observations here reported were made incidental to a study of biologies of Mexican anthophorid bees sponsored by the Associates in Tropical Biogeography, University of California.
2Identified by P. D. Hurd, Jr.

involved in these apparent color changes but the thirty-seven females were segregated as follows: eleven bright red, thirteen yellowish-orange, thirteen dull yellow. Although female mutillids are known to be long lived, these data would also indicate that the period of emergence in a single locality is of considerable duration.

Copulation was observed in a single instance while the authors were watching a bright red female which was walking up the road and into the light wind at about 6.45 p.m. Almost immediately after this female was first sighted three males were seen flying just above the surface of the ground and in a direct line toward the female from downwind. Less than twelve inches separated the three males and the closest flew directly to the female and initiated copulation without any prior courtship and before the other two males arrived. The other males left without contacting the copulating pair, which remained together motionless for five seconds. The duration of this period was timed with a stop watch and the pair was collected when the male abruptly terminated contact with the female. This male was later examined and had dull yellow pubescence and frayed wings which might further suggest that males of this species mate more than once.

Hurd (1951: 89) reports on an experiment conducted in the fall of 1947 in which "a number of small screen cages were set up in an area inhabited by several species of *Dasymutilla*. Females of *californica*, *coccineohirta*, and *sackenii* were collected between 1 and 3 p.m. and introduced individually into the cages which were grouped together in an open area. About 3.15 p.m. the first males were observed in the general area, but in no instance did they fly near the cages. At 3.30 p.m. what appeared to be a freshly emerged female *coccineohirta* was collected and placed in a cage in the same situation as occupied by the other cages. At 3.35 p.m. several males were noted about twenty-five feet away. At 3.40 a male flew in a large circle over the cages and landed beside the cage containing the freshly emerged *coccineohirta* female. The male attempted to enter the cage from all exposed sides, and after being permitted a few minutes of investigation, a try was made to capture him for introduction. The male, however, escaped and flew off, circling the area only to return to the same cage. The capture was then effected and he was introduced into the cage. After moving restlessly about for some moments, copulation of the pair took place, lasting only a few seconds. The group of cages was allowed to remain in the same area for another hour, during which time no additional males were observed to come near the cages. Upon return to the laboratory, the identification of the species which had undergone induced mating was verified as *coccineohirta*."

Hurd (1951: 90) reports that Dammers attracted males by means of females placed in small cages tied about his waist. Fattig (1943) also attracted males to females in small cages. These several observations on the activity pattern of the males seems to indicate that the primary attraction to unmated females involves an olfactory response. The apparent attraction of males to females by sight, as described above, may be a mechanism to insure mating of females which have exhausted their attractant during a period unfavourable for mating.

The lateness of the appearance of a presumably freshly emerged female, the brief period before the males were attracted, and the short period required for copulation were similar for *D. coccineohirta*, as reported by Hurd, and *D. formicalia*.

A few additional observations, which were made in the vicinity of the camp over a seven day period, should also be recorded. Females were collected in numbers during the first two hours of the morning and for a similar period in

the afternoon with occasional specimens being found throughout the day, particularly during periods of cloudiness. Males, however, were taken only in the morning and late afternoon being preceded by the females at each time. Males were seen to fly and approach females in the morning in the same manner as in the afternoon.

It would seem clear from these observations that *Dasymutilla pallida* Mickel (1937: 186) which was described from the male sex (type locality: Jalappa, Mexico) is the male of *D. formicalia* Rohwer (1912: 463) based upon a female from the Federal District, Mexico, and that the former name should be placed in synonymy.

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Encyrtidae from Trinidad, B.W.I.
1. Three Species of *Pseudaphycus* Reared from Mealybugs

By FRED D. BENNETT .
Commonwealth Institute of Biological Control

In the course of the study of parasites of mealybugs for introduction into West Africa for the control of mealybug vectors of cocoa virus a number of undescribed Encyrtids have been discovered in Trinidad, B.W.I. Descriptions of these and new Encyrtids reared from other hosts will be published in a series of papers.

The present paper records three species of *Pseudaphycus* from Trinidad, two of which are described as new. I am indebted to Mr. H. Compere who stated (in litt.) that the species herein described were probably new and pointed out the characters that separated them from related species. Dr. B. D. Burks kindly compared specimens of these species with types of related species deposited in the United States National Museum and suggested slight alterations in the manuscript which have been duly made.

1. *Pseudaphycus dysmicocci*, new species

This species runs to couplet 10 of Gahan's key to the species of *Pseudaphycus* (Proc. U.S. Nat. Mus. Vol. 96, pp. 311-327. 1946) but does not fit either section of the couplet. To separate this species insert the following between couplets 9 and 10.

10a. Frontovertex almost thrice as long as broad; ocellar triangle distinctly acute; dorsum of thorax brownish orange; first funicle segment pale, remaining ones fuscous; first club segment fuscous basally, rest of club white ..... *dysmicocci*, new species
Dorsum of thorax yellow or orange yellow, entire antennal club white 10

Female:—Length 0.8 mm. Frontovertex light orange; temple, cheeks and face below frons whitish grey; antennal scape pale below, dark above; pedicel

pale basally, dark apically; first funicle segment pale, others fuscous or black; first club segment fuscous basally, white apically, remaining club segments white. Ocelli dark reddish. Pronotum dark grey; mesoscutum and scutellum brownish orange; tegulae pale basally, fuscous apically; legs and underside of thorax pale, the middle and hind tibiae each with two more or less distinct fuscous bands; hind femur sometimes with a fuscous band near apex. Propodeum grey; dorsum of abdomen pale with fuscous markings, the venter pale. Wings uniformly faintly fuscous, almost hyaline; marginal vein darkly fuscous, other veins paler.

Frontovertex almost thrice as long as broad, granulosely punctate; inner orbits parallel or nearly so; ocelli in a distinctly acute angled triangle, the posterior ocelli about half as far from each other as from the anterior ocellus; eyes lightly clothed with minute whitish hairs. Scape only slightly expanded beneath, five to six times as long as thick; pedicel almost twice as long as thick, about one third as long as scape; first funicle segment narrower than pedicel, other segments of funicle subequal and subquadrate and each a little thicker than the pedicel; club thicker than last funicle segment and as long as the pedicel and funicle combined.

Mesoscutum, axillae and scutellum weakly sculptured, mat and clothed with short white hairs. Forewing with speculum closed at posterior margin of wing and also interrupted a little behind the middle; discal ciliation distad of speculum short and moderately dense, proximad of speculum a little coarser and not quite as dense; marginal vein punctiform, slightly shorter than postmarginal; stigmal vein distinctly longer than marginal and postmarginal combined.

Abdomen a little longer than thorax, at base about as broad as thorax and tapering to a point at apex; reticulately sculptured dorsally, smooth ventrally. Ovipositor exserted one third the length of abdomen.

Male:—Unknown.

Type locality: Mausica Road, Trinidad.

Type: U.S.N.M. No. 62854.

Remarks: Described from twelve females, holotype and paratypes, reared from *Dysmicoccus brevipes* (Ckll.) on pineapple. It develops as a solitary endoparasite of second-stage nymphs.

Additional specimens from the same locality were sent to Dr. D. C. Lloyd and Mr. H. Compere, California, in 1952.

2. *Pseudaphycus ferrisianae*, new species

Pseudaphycus sp. Kirkpatrick. A Report on Cacao Research, Entomological Section, p. 9, 1952.

In Gahan's key this species runs to couplet 6 and may be separated from other species by inserting the following after couplet 5,

6a. Speculum of forewing not interrupted 6
Speculum of forewing interrupted 7

and altering couplet six as follows:

6. Three rows of bristles present in anterior half of proximal margin of speculum; antennal funicle very dark brown, almost black, scape and pedicel mostly or entirely fuscous ... *ferrisianae*, new species

A single, closely set and slightly irregular row of bristles in anterior half of proximal margin of speculum of forewing; antennal scape, pedicel, and funicle uniformly very dark brown, almost black ..... *websteri* Timberlake

Female:—Length 0.95 mm. Frontovertex dusky orange; temples, cheeks and face below frons pale, tinged with orange; antennal scape fuscous with inner face and dorsal margin largely white; pedicel fuscous, funicle segments very dark

brown, almost black, club white; pronotum blackish, mesoscutum, axillae and scutellum brownish orange; tegulae pale basally, fuscous apically; underpart of thorax pale; legs whitish with all tarsi brownish. Propodeum and dorsum of abdomen dark brown, underside of abdomen lighter brown; ovipositor sheaths pale at base, dark brown apically. Forewing fuscous with a wide transverse hyaline streak beyond apex of stigmal vein; hind wing hyaline.

Frontovertex fully two and one-half times as long as broad, granulosely punctate; dorsal orbits of eyes diverging; ocelli in an acute angled triangle, the lateral pair about half their own diameter from eye margin, the front ocellus about two and one-half times its diameter from lateral ocelli; eyes sparsely clothed with short pile. Antennae strongly clavate; scape distinctly expanded below, about three and a half times as long as broad; pedicel a little more than one third as long as scape and nearly equal in length to the first four segments of funicle; funicular segments all transverse, subequal in length but successively increasing in width, the fifth segment being approximately twice as wide as the first and three times as broad as long; club large, indistinctly three-segmented, broader than last funicle segment and as long as entire funicle.

Mesoscutum, axillae and scutellum weakly sculptured, mat and clothed with short white hairs; propodeum smooth; mesopleura weakly reticulated. Forewing with discal cilia basad of speculum a little sparser and coarser than those distad; the speculum closed at posterior margin by several rows of hairs but otherwise uninterrupted; marginal vein longer than broad, stigmal vein longer than marginal and postmarginal combined.

Abdomen a little longer than and as broad as thorax, weakly sculptured dorsally, almost smooth ventrally; ovipositor sheaths exserted about half the length of the abdomen.

Male:—Length 0.74 mm. Scape not as strongly expanded as in female; scape and pedicel brownish, funicle blackish, club entire, white; wings almost hyaline. Otherwise similar in coloration to female.

Type locality: Imperial College of Tropical Agriculture, Trinidad, B.W.I.

Type: U.S.N.M. No. 62855.

Remarks: The holotype female, allotype, and a large number of paratypes of both sexes are the progeny of a few adults emerging from *Ferrisiana virgata* (Ckll.) collected from cocoa. This species is a gregarious endoparasite attacking second-stage to full-grown mealybugs, one to twenty individuals emerging from each host. Females outnumber males about four to one. It was shipped to the West Africa Cocoa Research Institute, Tafo, Gold Coast, West Africa, for liberation against mealybug vectors of virus disease of cocoa in 1953, and to the California Substation, Commonwealth Institute of Biological Control. Trials with several species of mealybugs, in Trinidad, West Africa and California indicate that this species attacks only *F. virgata*.

Specimens from the same stock were sent to Mr. H. Compere and Dr. D. C. Lloyd, California; Dr. W. R. Thompson, Ottawa, Canada. Further specimens have been placed in the collections of the Imperial College of Tropical Agriculture, Trinidad, B.W.I.

3. *Pseudaphycus utilis* Timb.

Pseudaphycus utilis Timberlake, Proc. Hawaiian Ent. Soc., vol. 5, p. 323, figs. 1-4, 1923. Swezey, Proc. Hawaiian Ent. Soc., vol. 5, p. 301, 1923. Timberlake, Proc. Hawaiian Ent. Soc., vol. 5, p. 431, 1923. Williams, Handbook of insects and other invertebrates of Hawaiian sugar cane fields, p. 255, 1931. Swezey, Proc.

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This species was originally described as a parasite of *Nipaecoccus nipae* (Maskell) from Mexico. Subsequently it has been successfully introduced into Hawaii and Puerto Rico where it has brought its host under satisfactory control.

In Trinidad specimens were reared from *Nipaecoccus nipae* (Maskell) on cocoa in January and April 1955, providing a new locality record for this species. The identity of this species was kindly confirmed by Dr. B. D. Burks who stated that the specimens are smaller and slightly lighter yellow than are the types of *utilis* and have a definite infuscation around the stigmal vein. However he was unable to find any structural differences between the two groups and considers them con-specific.

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ERRATA

In Vol. 87, p. 256, captions for Figs. 13 and 15 should be reversed, p. 261, line 5, (Fig. 30) should be (Fig. 16), line 6 (Figs. 11, 12) should be (Figs. 19, 20), line 7, (Fig. 3) should be (Fig. 26).

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